EFFECTS OF HIGH EMBANKMENT CONSTRUCTION ON ARCHAEOLOGICAL MATERIALS

FINAL REPORT # FHWA/CA/TL-83/02

CALTRANS STUDY # E79TL11

83-02

STATE OF CALIFORNIA
DEPARTMENT OF TRANSPORTATION
DIVISION OF CONSTRUCTION
OFFICE OF TRANSPORTATION LABORATORY

EFFECTS OF HIGH EMBANKMENT CONSTRUCTION ON ARCHAEOLOGICAL MATERIALS

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TECHNICAL REPORT STANDARD TITLE PAGE

1. REPORT NO.	2. GOVERNMENT ACCESSION NO.	3. RECIPIENT'S CATALOG NO.
FHWA/CA/TL-83/02		

4. TITLE AND SUBTITLE	5. REPORT DATE
EFFECTS OF HIGH EMBANKMENT CONSTRUCTION ON ARCHAEOLOGICAL MATERIALS	April 1983
	6. PERFORMING ORGANIZATION CODE
7. AUTHOR(S)	8. PERFORMING ORGANIZATION REPORT NO.
Alan Philip Garfinkel and Bobby L. Lister	19302-604184
9. PERFORMING ORGANIZATION NAME AND ADDRESS	10. WORK UNIT NO.
Office of Transportation Laboratory California Department of Transportation Sacramento, California 95819	11. CONTRACT OR GRANT NO. E79TL11
12. SPONSORING AGENCY NAME AND ADDRESS	13. TYPE OF REPORT & PERIOD COVERED
California Department of Transportation Sacramento, California 95807	Final
	14. SPONSORING AGENCY CODE

15. SUPPLEMENTARY NOTES

This study was conducted in cooperation with the U.S. Department of Transportation, Federal Highway Administration.

16. ABSTRACT

This report presents a field study conducted by Caltrans to determine the effects of constructing a 75 foot high embankment over a simulated Native American artifact site on Interstate 15 north of San Diego. The study consisted of excavating two small test units and placing three layers of artifacts in each simulated excavation unit. Artifacts were placed and mapped in each of the two units by Caltrans archaeologists with observers from the Luiseno tribe. Both units were instrumented with soil pressure meters and settlement platforms. A 60-inch culvert pipe with a 72-inch "T" section was used to provide access for the retrieval of the artifacts. A vertical well was drilled into the access pipe at the "T" section to monitor the ground water. Soil pressure meters were also placed near an actual artifact site on an adjacent project which was to be covered under deep embankment of height similar to the test site.

The results of this study supported the findings of a preliminary laboratory study performed by Caltrans District 11. The soil surrounding the artifacts consolidated one to two inches within the test sites. Fragile artifacts such as shell and bone suffered some minor damage while the stone artifacts were generally not affected.

Guidelines for preservation of archaeological sites on future construction sites are provided.

17. KEY WORDS	18. DISTRIBUTION STATEMENT
Archaeology, buried objects, embankments, instrumentation, Native American Artifacts, preservation, soil, pressure.	No Restrictions. This document is available to the public through the National Technical Information Service, Springfield, VA 22161.

19. SECURITY CLASSIF. (OF THIS REPORT)	20. SECURITY CLASSIF. (OF THIS PAGE)	21. NO. OF PAGES	22. PRICE
Unclassified	Unclassified		

DS-TL-1242 (Rev.6/76)

NOTICE

CONVERSION FACTORS

English to Metric System (SI) of Measurement

Quantity	English unit	Multiply by	To get metric equivalent
Length	inches (in)or(")	25.40 .02540	millimetres (mmm) metres (m)
	feet (ft)or(')	.3048	metres (m)
	miles (mi)	1.609	kilometres (km)
Area	square inches (in^2)	6.432×10^{-4}	square metres (m^2)
	square feet (ft^2) acres	.09290 .4047	square metres (m^2) hectares (ha)
Volume	gallons (gal)	3.785	litres (l)
	cubic feet (ft^3)	.02832	cubic metres (m^3)
	cubic yards (yd^3)	.7646	cubic metres (m^3)
Volume/Time (Flow)	cubic feet per second (ft^3/s)	28.317	litres per second (l/s)
	gallons per minute (gal/min)	.06309	litres per second (l/s)
Mass	pounds (lb)	.4536	kilograms (kg)
Velocity	miles per hour (mph) feet per second (fps)	.4470 .3048	metres per second (m/s) metres per second (m/s)
Acceleration	feet per second squared (ft/s^2)	.3048	metres per second squared (m/s^2)
	acceleration due to force of gravity (G)	9.807	metres per second squared (m/s^2)
Weight Density	pounds per cubic (lb/ft^3)	16.02	kilograms per cubic metre (kg/m^3)
Force	pounds (lbs) kips (1000 lbs)	4.448 4448	newtons (N) newtons (N)
Thermal Energy	British thermal unit (BTU)	1055	joules (J)
Mechanical Energy	foot-pounds (ft-lb) foot-kips (ft-k)	1.356 1356	joules (J) joules (J)
Bending Moment or Torque	inch-pounds (ft-lbs) foot-pounds (ft-lbs)	.1130 1.356	newton-metres (Nm) newton-metres (Nm)
Pressure	pounds per square inch (psi)	6895	pascals (Pa)
	pounds per square foot (psf)	47.88	pascals (Pa)
Stress Intensity	kips per square inch square root inch (ksi $\sqrt{in}$)	1.0988	mega pascals $\sqrt{metre}$ (MPa $\sqrt{m}$)
	pounds per square inch square root inch (psi $\sqrt{in}$)	1.0988	kilo pascals $\sqrt{metre}$ (KPa $\sqrt{m}$)
Plane Angle	degrees (°)	0.0175	radians (rad)
Temperature	degrees fahrenheit (F)	$\frac{tF - 32}{1.8} = tC$	degrees celsius (°C)

DEDICATION

This research report is dedicated to Robert D. Allen, Senior Transportation Engineer and District 11 Materials Engineer until his death May 4, 1981. Mr. Allen was a Co-Principal Investigator on this study and was instrumental in getting it underway.

Mr. Allen entered state service in 1947 after his discharge as a Marine Corps Officer. During his 34 year career with the Division of Highways, and subsequently Caltrans, he worked in three highway districts in positions with Construction, Design, Traffic, Freeway Operations and Materials.

He joined District 11 in January 1978 as District Materials Engineer; the same position he held in District 07 since 1968.

Mr. Allen was a 1944 Civil Engineering graduate of the University of Colorado.

His military service covered World War II and occupation duty from July 1, 1943 to June 6, 1946 and the Korean War from March 9, 1951 to June 27, 1952.

Mr. Allen was a dedicated civil engineer and was very thorough and professional in all his endeavors.

ACKNOWLEDGEMENTS

The authors wish to thank the following personnel of District 11 and Headquarters who were associated with this project:

DISTRICT 11

Environmental Branch Chief:	Tim Vasquez
Archaeologists:	
Cultural Resource Manager -	Chris White
	Doug Kupel
	Karen Crotteau
	Joan Decosta
Geologists:	Al Boost
	Joseph Egan
Minor Contracts:	Charles Gaunt
Construction:	Julie Carlin

HEADQUARTERS

Archaeologists:	Roger Cook
	Sheila Mone
Instrumentation Specialists:	Frank Champion
	Ron Thompson
Photographers:	Robert Mortensen
	Pete Asano
Word Processing:	Darla Bailey

Special thanks is also extended to Vic Lind and Hal Clarke, Senior Resident Engineer and Resident Engineer, respectively.

Appreciation is also extended to the following Native Americans for their cooperation and observance of the placement and excavation of the artifacts:

Native Americans:	Kevin Denver
	Henry Rodriquez
	Ben Magante
	Lester Nelson

We also extend our appreciation to the Department of Parks and Recreation for their provision of artifacts included in this study. Specifically, Fritz Riddell, Dwight Dutschke and John Foster, of their staff, were of direct assistance giving needed advice and consultation on the subject of Native American coordination and also methodological issues.

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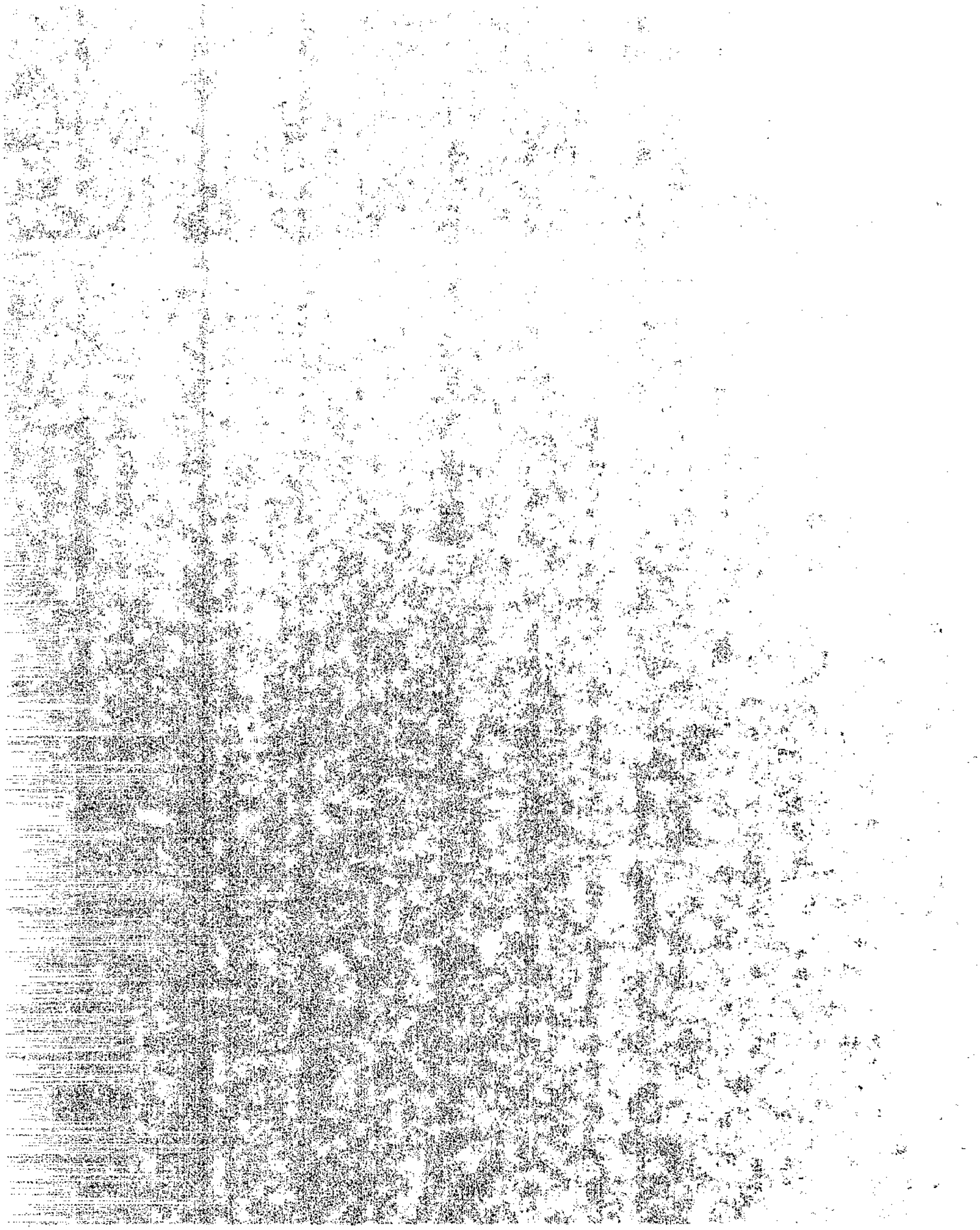

LIST OF PHOTOGRAPHS (Cont'd)

LIST OF PHOTOGRAPHS (Cont'd)

I. INTRODUCTION

Transportation corridors often cross areas containing archaeological resources. In many cases, a proposed transportation project can be economically designed to avoid these archaeological sites. However, when engineering and safety considerations require routing the alignment through or over them, every effort is made to minimize the impacts; sometimes by placing a fill over the site and conducting various levels of archaeological study. The effects of embankment construction and the placement of high fills on archaeological sites is of special concern to archaeologists, Native Americans and the California Department of Transportation (Caltrans).

This report presents the results of a field experiment to determine the effects of high embankment construction on archaeological remains. The study evaluates the gross changes in artifact condition due to large overburden pressures from the fill material. Also presented are the results of laboratory tests on midden soil and decomposed granite (D.G.) samples obtained from archaeological sites in Caltrans District 11. The tests consisted of consolidation of undisturbed midden soil, vertical compression of artifacts embedded in midden soil and chemical analysis of both the midden soil and the D.G. cover material.

The study's design, limitations, conclusions, recommendations and guidelines are presented herein.

A. Research Objectives

The specific objective of the research project was to determine the effects of constructing a 75-foot high embankment on simulated archaeological material by analysis of:

1. Horizontal and vertical pressures of the embankment using soil pressure meters at each test unit.

2. The settlement of the soil covering the artifacts in the test units using sealed standpipe settlement platforms.

3. Chemical changes of the soil around the artifacts between the time of placement and the time of retrieval of the artifacts.

4. Ground water fluctuation at approximately the same elevation and location as the artifact test units.

5. Gross changes in condition and displacement of artifacts caused by the horizontal and vertical pressures due to the presence of a high embankment fill.

II. CONCLUSIONS

1. The results of the field study supported the District 11 laboratory study which suggested that a loading equivalent to 75 feet of embankment over archaeological sites would produce limited damage to the artifacts. It can be concluded that placement of artifacts under high embankment construction causes limited gross morphological changes in these objects.

2. Limited damage occurred to the artifacts as a result of deep embankment construction. Charcoal strips placed with the artifacts were slightly bowed but otherwise undamaged after retrieval. Some faunal remains were damaged and one very fragile "sand dollar" was badly fractured. Also, a small obsidian flake was damaged.

3. Some limited chemical changes were evident in the soil surrounding the artifacts after two years of artifact placement. These changes may be significant, however, long-term studies are needed to evaluate the effects of the limited changes noted.

4. There was no evidence that ground water had risen into the artifact unit at Locus A. The moisture content remained a constant 10% from the time of artifact placement to the time of artifact retrieval and water was not present in the vertical well at the time of artifact retrieval. However, the soil surrounding the artifacts was very moist.

5. The soil pressure at Locus A indicated by the soil pressure meters was 53 psi vertically and 3 psi horizontally. The calculated theoretical vertical pressure was slightly higher than indicated by the soil pressure meter. This was probably due to bridging of the soil.

6. Settlement of the soil within the two artifact units was less than three inches and was well within the consolidation limits predicted from laboratory tests.

7. The total settlement of the foundation under the embankment at the artifact site was 7.9 inches at Locus A and 9.1 inches at Locus B. This is normal anticipated settlement in this sandy, silty foundation type material loaded with approximately 75 feet of embankment.

8. While there was some lack of complete documentation on the before placement condition of certain artifacts subject to this study, both the laboratory and the field study did establish that archaeological materials when placed under high embankment construction exhibit limited gross morphological changes.

III. RECOMMENDATIONS AND GUIDELINES

A. Recommendations

High embankment placement over known archaeological sites may be used to help preserve historical sites. The suggested procedure could be as follows:

1. All significant historical sites should be subject to an archaeological review with sufficient excavation to evaluate each site prior to embankment cover.

2. Although not used in this study, a permeable geotextile fabric could be placed over the site prior to embankment construction as a separator between the midden soil and the new embankment. This should be followed by placement of one to three feet of uncompacted fine grained soil, i.e., decomposed granite, then normal embankment construction.

B. Guidelines

This study concludes that the construction of high embankments over archaeological materials produces limited changes in the gross condition of archaeological materials. These results should be used with consideration to the following guidelines (cf. U.S.D.I. 1976).

1. Burial of sites under fill can disturb surface or near surface cultural material. Hence it may not be an appropriate procedure for sites with extensive fragile surface pattern remains.

2. Fill materials should be selected which would minimize chemical contamination of the site (e.g., decomposed granite fill).

3. Fill material should be placed in such a way as to preclude heavy vehicular disturbances to the site and fill material should be used which will not inadvertently damage the integrity of the deposit (e.g., heavy wheeled vehicles using large rock or concrete fragments would not be appropriate, etc.).

4. Burial often precludes the possibility of archaeological research at the buried deposit. The burial process is an action which allows further deterioration of the remains while precluding the possibility of recording information on the site. Hence only those sites not high in organic remains would be good candidates for fill material placement as a preservation aid.

Furthermore, an effort should be made to excavate a portion of a site which will be covered to learn what type of remains are being buried so as to provide an index for future researchers if and when the need arises to relocate the site and excavate it.

5. The location of a site to be buried must be formally delineated. After much time has elapsed, landmarks change, survey benchmarks are lost and the site may be impossible to relocate. Inadvertent damage may occur if the site is exhumed accidentally, or the site may simply be lost.

6. Burial of an archaeological site may be the most appropriate part of a mitigation plan when a portion of the site is excavated and the remainder carefully covered. When a complete systematic excavation is not possible, a combined limited excavation and burial is preferred to partial excavation and destruction of the remainder of the site.

7. Consideration should also be given to location of water table and possible inundation of the site which could lead to potential chemical changes.

8. Ethnic concerns play a vital role in determining the appropriateness of a fill. California Native American cemeteries (recorded or not) are treated by law as special cases. They are given the same protection as other cemeteries but have special protection provisions.

IV. IMPLEMENTATION

The results of this research project can be used for developing guidelines for embankment construction over known archaeological sites. These efforts will be made in coordination with archaeological investigations. The implementation will be by the Design, Construction and Environmental Planning Branches within Caltrans Headquarters and the particular District involved.

V. FUTURE RESEARCH CONSIDERATIONS

The effects of deep burial had never been studied prior to this project and the primary objective was to identify gross changes in the artifact materials. Both the laboratory testing and the field research indicated limited gross changes in the artifactual materials and it is felt that future studies should focus on a finer level of analysis. The present study is certainly far from definitive since the small scale effects (i.e., minor fracturing, chipping, etc.) were not analyzed as part of this study.

Future research on the effects of high embankment construction over archaeological materials should be more detailed and take the following into account:

1. Detailed documentation must be made regarding the state of the research materials (artifacts) prior to burial. As examples:

    a. All objects/materials should be photographed in fine detail (artifact manufacture, edge damage) in order to show all sides or portions of an item. Microscopic photographs might also be included.

    b. Records of the locations of objects should be highly detailed and present specifics of depth/orientation/cardinal direction/etc.

    c. Rectified photographic images of in situ artifacts could provide additional information on the location of each object relative to other objects in the same excavation level.

d. A permanent vertical datum should be developed which would allow precise location of the objects to be analyzed.

e. A broader spectrum of archaeological materials should be tested for the effects of high embankment construction. Similarly, various types of soil have different compaction characteristics; these could also be evaluated.

f. More detailed sampling and analysis of the soils surrounding the artifacts and those within the embankment fill is necessary. A site containing soils identical to those surrounding the artifacts themselves and unaffected by the embankment construction should be used as a control and for comparative study.

g. A study of longer duration should be conducted to evaluate whether the time element would have any further effects on the simulated archaeological site and its materials.

Considering the limitations of the present study, the level of analysis is general in nature. It was reasonable to detail simply the condition and displacement of the materials but determinations could not be made concerning minute damage patterns.

VI. HISTORICAL BACKGROUND

The High Embankment Archaeological Preservation study represents one element in a continuing discussion regarding the use of fill as a mitigation measure to lessen impacts to archaeological sites. In the early 1970s, archaeologists faced with the problem of devising cost-effective ways to minimize the damage from various construction projects developed a number of ways to "preserve" archaeological sites (King et al. 1973). One of these means was to place a low fill over the sites without seriously damaging them (King et al. 1973:14). King and his colleagues stated that although the latter technique is useful, little information existed on the effects of covering a site with fill material; i.e., compaction or the subtle changes in soil chemistry which may result in loss of important information when a site is covered with fill. "Nevertheless, burial in many cases may prove to be the best way of maintaining sites in a sort of "bank" for investigation hundreds or thousands of years in the future". Although archaeologists were not united in their approval of this technique, it was used as a compromise solution in a number of instances during the early 1970s.

During the planning and development of a new portion of Interstate 15 in San Diego, Caltrans identified several archaeological sites which were to be adversely affected by the construction project. In order to reduce impacts to the sites, large amounts of fill were to be placed over them. This, in part, was due to topographical considerations which limited design solutions for site avoidance. At this time, Caltrans began to explore the effects of placing high embankments over archaeological sites (Caltrans 1978a, 1978b). Laboratory tests were conducted to simulate the effects of high embankment fill on archaeological materials. The results of these initial tests are fully reported in the body of this report.

In 1976, the Department of the Interior issued an analysis and policy statement on the "Non-aqueous burial of archaeological sites" (United States Department of the Interior 1976). The policy statement emphasized the lack of knowledge surrounding the practice of covering over a site suggesting that there was no basis to justify the assumption that the covering of a site with fill will have <u>no</u> effect on it.

The policy statement mentioned a number of archaeological site characteristics which might make them especially susceptible to damage by the simple process of placing a fill over them. The policy statement directs that:

> "...the burial of an archaeological site is considered to constitute adequate avoidance or mitigation only when all of the following conditions can reasonably be demonstrated to pertain: 1) the site is already substantially buried, or has a very resistant surface, or a seriously disturbed surface, and covering will not physically damage the surface; 2) reliable pedological studies indicate that the soils to be covered will not suffer serious compaction; 3) the covering materials are not chemically active; 4) the natural processes of deterioration have been effectively arrested; 5) the site is fully recorded, marked, and protected insofar as is possible to guard against accidental damage during exhumation."

More recently, the Advisory Council published a handbook suggesting guidelines for the treatment of archaeological properties (A.C.H.P. 1980). This handbook reinforces those policy statements made previously and also refines them slightly. It is indicated that the covering of an archaeological site with fill can only be considered a reasonable adequate mitigation measure when "access can be assured within reason for future research" and when test excavations have taken place so a reasonable record of what has been covered exists (A.C.H.P. 1980:14). This is considered a critical element and would be an important factor for consideration if high fill was to be used more routinely as a preservation device. Whether such a procedure would be considered an adverse effect has yet to be clarified.

In the recent Orientation Guide, issued by the Federal Highway Administration for use during its instruction on the 106 process (United States Department of Transportation n.d.), mention is again made of the use of "incorporation" or burial as a means of preservation. They state that it may be possible to preserve a resource by "building the highway on top of it". However, they again indicate that this may be a questionable measure and that archaeologists disagree on the wisdom of such a technique. They also cite the present research effort as an endeavor to gain more reliable information on the effects of compression, soil composition, chemical changes and other elements on buried archaeological sites (U.S.D.O.T. n.d. 4-15).

VII. DISCUSSION

A. Preliminary Laboratory Tests

In late 1977, the Project Development Branch of Caltrans District 11 requested consolidation tests for two archaeological sites (CA-SDi 4807 and 4808) from the District 11 Materials Laboratory. Consolidation tests were performed on undisturbed samples obtained from two borings at each site using a 2-inch California Sampler. Samples were contained in 2 inch x 4 inch brass liners. Tests were under controlled compressive, vertical loadings, with the liners providing horizontal confinement. Loadings represented 14 feet, 24 feet, 42 feet or 45 feet and 75 feet of fill having a density of 133 lbs/ft^3. Changes in sample height vs loading were then applied to the total soil thickness to determine consolidation. The results of the consolidation tests indicated settlements of from one inch to 3.7 inches for CA-SDi-4807 and from 0.5 inch to 3.0 inches for CA-SDi-4808 with an average of 1.9 inches and 1.6 inches, respectively.

B. Expanded Laboratory Tests

On March 13, 1978, the Project Development Branch of Caltrans, District 11, requested additional data which created the need for further testing and research. The following tests and information were requested:

1. Suggested rate of loading over the archaeology sites CA-SDi-4807 and 4808.

2. Effects of consolidation of the midden.

3. A chemical analysis of the decomposed granite (D.G.) that was to be used to provide one foot of cover over midden areas at archaeological sites CA-SDi-4556, 4807 and 4808.

Samples of the midden and D.G., which would be used as the cover, were shipped to the Transportation Laboratory of Caltrans for chemical analysis.

District geotechnical and materials personnel, meanwhile, performed additional load testing on selected items incorporated in midden soils to provide information for rate of loading and effects of consolidation. Testing was performed on marine invertebrate shells, small mammal and bird bones and moderately thick potsherds to evaluate the effects of simulated fill loads. Midden soils from sites CA-SDi-4556, 4807 and 4808 were used for these tests. The items to be tested were embedded at random in the soils and subjected to pressures equivalent to the maximum height of the fill loads (heights of 9, 45 and 74 feet, respectively). Refer to Appendix A.

As a result of this testing, the District Materials Branch concluded that:

1. A practical rate of embankment placement over sites CA-SDi-4556 and 4807 was two feet or less per day. Since soil was less compressive at site CA-SDi-4808, a placement rate of four feet per day could be tolerated.

2. That consolidation of the midden would:

a. Have little or no effect on stone tools.

b. Have only minor effects on bone since most bone tested was already fragmented.

Additional data obtained from laboratory testing prompted the following observations:

1. Artifact breakage under fill loads would be negligible.

2. Effects of midden soil consolidation might not be discernible since midden bases vary from spongy leaf mold to compact D.G. and/or rock.

On March 21, 1978, a supplemental memorandum (Appendix A) provided additional comments, test procedures, results and conclusions, along with sketches of artifacts, photographs and test data.

Chemical analyses from the Transportation Laboratory in Sacramento were presented with the District Laboratory pH and moisture test results in a memorandum dated March 21, 1978 (Appendix B). It was concluded in this memorandum that no evidence was obtained that would suggest a significant chemical change in midden soils if they were covered by a one foot layer of D.G.

Soil samples were collected from sites SDi-4566, 4807 and 4808 and from two D.G. locations in a designated area at a depth of 10 to 12 feet below original ground. pH and moisture tests were run on these samples by the District

11 laboratory. Material passing the #8 sieve was soaked in deionized water to put soluble salts in solution. One pint of liquid was drawn from each sample and shipped to the Transportation Laboratory for chemical analysis employing atomic absorption spectrophotometry (see Table 1).

The one constituent of the D.G. leachate which might alter the site soil would be sodium. The ratio of sodium between the D.G. and the sites was 5 to 1. Whether additional sodium would cause a significant change in midden condition or subsequent interpretations is unknown.

The pH values of the D.G. samples (6.5 and 6.8) are within the range of site soils (6.2 to 8.3) and would cause no substantial changes in pH values.

The potassium range for midden soils is 8.18 to 18.18 parts per million of dry midden because of organic content. Ratio of midden potassium to D.G. potassium is as high as 15 to 1. Therefore, a change in midden chemistry for this element would not result from leachate from a D.G. cover.

No evidence was obtained that would suggest significant chemical changes in midden soils if covered by a one foot layer of D.G.

C. Field Experiment

1. General Discussion

A test site was selected for the field experiment 1.5 miles north of Gopher Canyon Road at a location on the I-15 project, Figure 1. Site geometry was a primary factor in this choice since approximately 75 feet of embankment would be placed over the site during construction.

Two artifact test units were selected and are identified as Locus "A" and "B" in Figure 2. These were situated 30 feet apart, parallel to the freeway centerline, and approximately 130 feet into the fill from the toe of slope. A 60-inch culvert pipe with a 72-inch "T" section was used to make the excavation units accessible (Photo 1).

D. Artifact Placement

The test units were mapped in-place and tied to centerline stationing. The test area, approximately 250 feet square, was first hand cleared of all grass and brush to minimize disturbance to the native soil. A 6-foot square was initially excavated at each locus to a depth of 18 inches (Photo 2). The bottom was leveled then moistened, compacted and density-moisture tests (Table 2) were taken with a nuclear gauge (Photo 3). In the center of each excavated test site, a one meter square was laid out and a 10 cm grid superimposed over the ground surface using nylon string and wood stakes (Photo 4). Artifactual material was placed within these excavation units within the grid. The placement and mapping of the artifacts was conducted on October 23-25, 1979 by two Headquarters archaeologists, Roger Cook and Sheila Mone.

Three 10 cm levels were constructed and labeled 0-10, 10-20 and 20-30 cm from top to bottom, respectively. The artifactual and noncultural material was placed at the base of each "level". Notes were taken concerning the placement of these materials and photographs of each level were made (Photos 5 through 7). The artifacts and other objects were carefully covered with backfill by hand to simulate excavation level increments and vertical cultural stratigraphy. The backfill, a fine, sandy loam, was watered to insure uniform compaction. The two units were completed in this fashion (Photos 8 and 9).

There were some concerns aired by the local Native American population, the Luiseno, over the potential use of aboriginal artifacts in this research project. The Luiseno believe that aboriginal artifacts should be left undisturbed and not used for scientific purposes. Due to this concern, the material used in this research was either of recent manufacture or archaeological materials of unknown derivation. The former items were, in part, manufactured by Dwight Dutschke, Cultural Resources Section, Department of Parks and Recreation. The latter objects derived from this agency as well. Representatives of the Luiseno Tribe approved this material for research purposes.

Some of the items used were recently replicated artifacts manufactured of similar materials to those recovered in a prehistoric context. These included: a large basalt biface, a large grey obsidian biface, three chert core fragments, nine unmodified obsidian flakes, five small obsidian bifaces or projectile points, three complete _Olivella_ sp. shells, three _Olivella_ sp. disc "beads", four cut and formed fragments of abalone (_Haliotis_) shell, three granite manos and a centrally-notched obsidian biface.

Also present were the items of unknown aboriginal origin or fairly recent historic derivation including two granite manos, a fragmentary arrow shaft straightener, a granitic metate fragment, a small Mexican ceramic pot, unmodified fragments, complete examples of marine invertebrate remains, and a collection of historic faunal material consisting of fragmentary animal bone principally from domestic species. These latter items were derived from a sample of excavated material from the Hotel de France in the old part of Sacramento.

Also introduced into the excavation units were a number of granite cobbles which were used to create a variety of common archaeological features. Artists charcoal sticks of various hardnesses were added to the array of objects to be placed based on the suggestion that they would be a good indicator of potential artifact damage (see Table 3).

All flaked stone, ground stone, shell, and pottery were photographed prior to placement within the excavation units (Photos 10 through 16). Unfortunately, preplacement close-up photographs of the shell, bone and charcoal are not available. The placement of the artifacts in each level of both test units is shown in Photos 5 through 7 for Locus A and Photos 17 through 19 for Locus B.

Three Native American (Luiseño) observers (Henry Rodriquez, Ben Magante and Lester Nelson) witnessed the excavation and placement of the artifacts in the test area.

E. Instrumentation of Test Site

Instrumentation to monitor maximum earth pressure and settlement was installed by the Transportation Laboratory as the material in the two test units was brought up to the original ground level.

1. Soil Pressure Meters

Two soil pressure meters were placed just outside each of the test units and near the depth of the middle layer of artifacts (10-20 cm level). The soil pressure meters were installed so that the horizontal pressure and the vertical pressure parallel to the freeway centerline could be monitored periodically (Photo 20).

2. Settlement Platforms

Two fluid type settlement platforms (Figure 3) were placed adjacent to each test unit, one at the bottom elevation of the test excavations and one at the original ground elevation (Photo 21). The settlement platforms were installed at these two levels to determine the actual settlement or compression of the artifact stratum and also monitor total settlement of the test area under embankment loading.

3. Instrumentation and Artifact Protection

An 18-inch cover of D.G. was placed over the artifact units and the instrumentation to provide extra protection before the embankment construction began (Photo 22).

4. Water Well

An 8-inch diameter vertical well was drilled through the bottom of the 72-inch diameter corregated metal pipe (CMP) "T" section access pipe to a depth of approximately 7 feet and was cased with a 2-inch slotted PVC pipe. The well was installed for monitoring periodically to determine if the water table rose above the base of the fill during the winter season.

F. Instrumentation Near an Actual Archaeology Site

1. Soil Pressure Meters

Two soil pressure meters were installed on an adjacent project near an actual Native American artifact site. The installation of the pressure meters was the same as the test unit installation (see Photo 20). The meters were placed to monitor horizontal and vertical earth pressures parallel to the freeway centerline. They were installed to compare the soil pressures at the test site with an actual artifact site having approximately the same height of embankment. However, both soil pressure meters malfunctioned during the early construction phase which eliminated any possible comparison of earth pressure data.

G. Soil Sampling

Samples of the soil used to cover the artifacts and the decomposed granite used to cover the artifact units were collected for chemical analysis (Table 4) and other laboratory tests by the Transportation Laboratory. Triaxial tests were eliminated from this study since the actual construction of 75 feet of embankment showed damage to only a few of the more fragile artifacts. Minimal damage to artifacts was also experienced during preliminary laboratory direct compression testing of simulated artifacts.

1. Chemical Analysis

Chemical analyses were performed on three soil samples, 1) soil surrounding the artifacts during artifact placement, 2) soil surrounding the artifacts during artifact retrieval and 3) the decomposed granite cover during artifact placement. Some variations in test results for the concentration of the chemical elements were detected. These results prompted analyzing additional samples of the same soils. The results shown in Table 4 present some variation between results of samples obtained during artifact placement and during artifact retrieval. These differences in chemical element concentrations may be significant. It appears that certain chemical elements may have leached out of the soil during the study period. Phosphorus, calcium, magnesium, potassium and zinc decreased. Sodium remained at about the same level or increased slightly in concentration. The reasons for these changes are unclear. One possible explanation is that the chemicals were extracted by water due to possible percolation through the fill. This assumption may be useful in understanding the relative stability or slight increase in sodium. Sodium is most likely to move with water and is the most soluble of the chemical elements tested. It was also the only element found in comparatively higher concentration in the decomposed granite fill overburden as compared to the material covering the artifacts. Given this chemical's water solubility and increased concentrations in the material above the artifacts, if this element were being leached out from above, it could have introduced additional sodium into the soil covering the artifacts themselves.

The above hypothesis to account for the changes is simply speculation. Further studies could explain such changes and also the long-term effects of high embankment construction on soil chemistry.

H. Embankment Placement and Access Tunnels

Embankment construction began on January 8, 1979 by placing and compacting approximately six feet of material from the toe of slope up to, but not on, the artifact placement sites. A trench was then excavated for the installation of the 60-inch diameter corrugated metal pipe (CMP) for access through the six feet of fill from the toe of slope to the center of the artifact units. A 72-inch diameter CMP "T" section was then placed on centerline extending to within ±5 feet of the two artifact units (Figure 2). The 60-inch diameter access pipe was connected to the 72-inch CMP to form a "T" section when installed in the trench, daylighting at the toe of slope. Timber bulkheads and struts were installed at all three ends of the "T" to keep material out of the pipe during construction.

A 12-inch diameter section of CMP was attached to the top and in the center of the 72-inch diameter "T" section. The 12-inch CMP was brought up through the fill during construction to provide ventilation in the access tunnels (Photo 1).

After backfilling the access pipes, the embankment was constructed over the artifact units to a finished height of 75 feet on April 17, 1980 (Photo 23).

I. Instrumentation Readout

1. Settlement Platforms

The differences of the upper and lower settlement platforms initial and final readings in Locus A and Locus B were 2.76

inches and 2.64 inches, respectively. These readings indicate that the settlement or consolidation within the artifact placement units was well within the values predicted by laboratory consolidation tests of 1.0 to 3.7 inches and 0.5 to 3.0 inches under 75 feet of embankment. The total settlement of the foundation plus the soils within the artifact placement units was 7.9 inches at Locus A and 9.1 inches at Locus B. This is considered normal settlement for this type of material loaded with approximately 75 feet of fill.

2. Soil Pressure Meters

The two soil pressure meters installed at Locus A indicated a vertical pressure of 53 psi and a horizontal pressure of 3 psi. The calculated theoretical vertical pressure was somewhat greater than that indicated by the soil meter pressure. Based upon an average density of 133 lbs/ft^3 and 75 feet of embankment, the calculated theoretical pressure was 69 psi. The 53 psi indicated by the soil pressure meter is probably closer to the actual pressure on the artifacts due to bridging of the soil load during construction.

Both soil pressure meters at Locus B malfunctioned as the embankment was constructed.

3. Water Well

Personnel safety considerations precluded taking water level measurements during construction as planned. Entrance to the access pipe was sealed off by the installation of a bulkhead and fill material placed around it. However, water was not present in the vertical well at the time of artifact retrieval.

J. Artifact Retrieval

In August 1981, arrangements were made to unearth the artifacts in Locus A (refer to Figure 2) which had been placed beneath 40 to 75 feet of fill for one year and eight months. Locus B remains unexcavated and is still available for study.

Shoring for the retrieval of the artifacts from Locus A was arranged by Charles Gaunt of District 11 under a minor contract. Less than a week was anticipated for completion of the shoring of an area 10 feet wide by 8 feet long at the southern end of the "T" section (Locus A). After initiating the excavation, the contractors found that the area to be shored contained large granite boulders, some weighing several hundred pounds which caused a delay. The presence of these large boulders was not anticipated. Fill was to have consisted of soil or decomposed granite. In any case, further work was halted until the contractor could perform the necessary shoring which was made difficult by the heavy, angular granitic boulders. To insure the safety of those working below, a District 11 mudjack crew was brought to inject cement grout under high pressure up over and behind the wooden shoring. This procedure filled all substantial voids and prevented the boulders from falling onto the shoring.

Formal archaeological retrieval at the site began on August 10, 1981. Five individuals were directly involved in the work. A Caltrans Headquarters Archaeologist, Alan Garfinkel, served as the director for the retrieval process. Three District 11 archaeologists participated in the work. Doug Kupel acted as crew chief and excavator with Karen Crotteau (note taker) and Joan Decosta (screener). A Native American from the Pala Indian Reservation, Kevin Denver, acted as an observer and assisted in the excavation.

The retrieval procedure was aided by lights hung along the 130 foot 60-inch pipe and into the "T" section to illuminate the work space. A photographic light bar was also used when additional light was needed for special close-up photography and fine work (Photo 24). Ventilation was provided by a 12-inch CMP running vertical from the access pipe to the surface which was placed during construction (Photo 25). A blower fan was attached to the pipe and was used continuously to allow better air circulation. In addition, a portable fan was used when the temperature and moisture content of the air became unbearable. A portable generator was used throughout the project to provide power for lights and ventilation. Due to equipment malfunctions and necessary maintenance, a significant amount of "down time" occurred with the generator.

The entire underground work area was considered a "confined space" (Photo 26). Consequently, special consideration was given to safety. Each day that any subsurface work was scheduled, pre-entry atmospheric testing took place. Tests were conducted to determine that (1) sufficient oxygen was present and (2) that gases (if present) were below a harmful level. In addition to atmospheric testing, the shoring was monitored with listening equipment to pick up and amplify subaudible noise generated by stress. No subaudible noise was detected during the monitoring periods.

Rapid communication was made available by radio through District 11 relay to the Deer Springs Fire Department. The

California Occupational Safety and Health Act (CAL-O.S.H.A.) standards and California Division of Industrial Safety, Construction Safety Orders were closely followed for all aspects of tunnel design including shoring, lighting and ventilation.

Careful attention was given to coordination between Caltrans, the Native American community, the media (newspapers, radio and television), the archaeological community and the general public. This was accomplished through the efforts of Chris White, the District 11 Heritage Preservation Coordinator and District 11 Public Information Officer, Jim Larson.

One individual completed the entire artifact retrieval process due, in part, to space limitations and so as to allow a uniform technique and better control of data acquisition. Initial shovel excavation identified the level at which the material was present. The excavator, using only trowel and paintbrush or finer equipment (Photo 27), slowly peeled away the soil matrix over the cultural material. All efforts were made to recover and record the data in place. Since it was possible that the objects may have moved or fragmented during the time they lay under the fill material and thus would not be in their original position, a plan was developed for the examination of the soil removed from Locus A. Soil removed throughout the excavation was placed in a plastic bucket (Photo 27) which, in turn, was emptied into a wheelbarrow and wheeled from Locus A down the main tunnel and outside to be screened. The fill material was examined using 1/16 inch mesh hardware cloth to allow recovery of the smaller fragments of cultural material. It is important to note here that the disposal of the soil matrix from the excavation was time consuming and laborious. Since the tunnel was only five feet in height, it allowed only a crouched stance while exiting the tunnel with the wheelbarrow.

Some difficulties were encountered during the excavation. It was presumed that the test area was five feet from the end of the corrugated steel access pipe ("T" section) and was oriented in the same manner as the tunnel. This proved to be incorrect when it was revealed that the series of stakes outlining the northern edge of the excavated unit were only 20 inches in from the timber shoring and 7.5 feet out from the end of the corrugated metal pipe. The test unit laid at a different orientation than the pipe, i.e., along magnetic north-south lines. Most importantly, a large portion of the unit lay beneath the westerly timber shoring of the tunnel (Photo 28, Figure 4).

This discrepancy was possibly due to movement of the culvert during placement and/or during subsequent backfill and embankment placement.

Safety considerations precluded working under the shored walls which required expansion of the tunnel excavation. When the inside position discrepancy was discussed with District 11 engineers, a decision was made to temporarily halt the retrieval effort.

The partial archaeological excavation was backfilled and the shoring contractor returned to enlarge the working space and make as much of the unit available for data retrieval as possible. The shored area was lengthened and widened. An additional 3.5 feet of tunnel length and 1.25 feet of breadth was excavated. Due to the cement grout casing, a jack hammer was necessary to carry out the work which added increased costs to the shoring contract.

Excavation for artifact retrieval resumed on August 24, 1981. Some difficulties were encountered in clearing the soil away from the stakes due to the confined conditions and a record heat wave which escalated temperatures within the tunnel. Mechanical problems with the generator further hampered these efforts.

The material from the first level was exposed on August 26 and photographs were taken of the objects as they lay on the nylon string grid (Photo 29). The original documentation included only oblique photos of the excavation level. These photographs could, therefore, not actually be used for comparative purposes.

Additionally, Pete Asano, from Headquarters Photographic Services, completed a rectified photographic image with a 4x5 camera. This picture is included for comparative purposes (Photo 29a).

The material was carefully mapped in place and then removed. It was further photographed and examined outside the tunnel and notes were taken as to the condition of the various items, compared to their original state when placed in the test area (Photos 29 through 34).

Each excavation level was completed in the same manner with almost all material uncovered in place in the ground and not during the screening process. Small bone fragments and an obsidian flake were identified during the screening process but for almost the entire period of matrix evaluation, retrieved material was identified directly by the excavator.

Density-moisture tests were taken with a nuclear gauge on the bottom of the test site after the artifact retrieval was completed. Table 2 compares the results of the density and moisture tests before placing and after retrieval of the artifacts.

Excavation and backfill work was completed on August 28, 1981.

K. Artifact Condition Evaluation

In discussing the condition of the artifacts after excavation, it is important to keep in mind that this study was limited to analyzing gross changes. Recommendations for more refined deep burial experiments are contained in Section V (Future Research Considerations). The following general and specific changes observed as a result of this study are presented below.

1. Level 1 (0-10 cm)

Material from this level appeared to have little or no damage. The charcoal sticks were bowed but unbroken (Photos 35 and 36). The *Olivella* shell disc "beads" lightened in color, but were complete. Other material was in a similar state.

2. Level 2 (10-20 cm)

Faunal remains showed signs of damage. A marine invertebrate "sand dollar" was badly fractured (Photo 37). It had broken into pieces, some of which were barely 1/8 inch square. Other shell remains showed either minor edge damage, hairline fractures or were physically broken. The faunal material was moisture laden and fragile, showing fresh fractures and recent decomposition especially on the ends of "long" bones. A mammalian rib bone exhibited parallel fractures and was fragile. However, ground and flaked stone objects were complete and appeared undamaged. Charcoal sticks were bowed but unbroken (Photo 38).

Before reaching Level 3, four obsidian flaked stone items were discovered for which there existed no prior documentation. The archaeologists involved have no knowledge of the placement of these objects. In any event, they all appeared in good condition.

3. Level 3 (20-30 cm)

In general, faunal remains were damaged. Larger elements were very friable and had hairline fractures. A section of innominate bone had broken in two. An unmodified marine invertebrate shell was cracked on its edge and contained a hairline fracture. Formalized shell artifacts appeared unimpaired by their burial. Ground and flaked stone items were undamaged as were the charcoal sticks although bowed. One obsidian flaked stone item (a linear flake) was broken on its proximal end (a small fragment of this item was found during screening).

L. Displacement

It is difficult to assess relative movement without more adequate comparative material, but judging from the existing photographs and documentation, there appeared to be little vertical or horizontal movement of any of the retrieved research material. Charcoal sticks in the 0-10 cm and 10-20 cm levels showed some horizontal displacement. Vertical displacement cannot be measured exactly as no previous calculations relating to a permanent datum were made. However, judging from photographs and notes, the excavating team thought that some downward movement of artifacts had taken place on the order of 2 to 3 cm. This is consistent with settlement platform data.

VIII. BIBLIOGRAPHY

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IX. TABLES

TABLE 1

PRELIMINARY LABORATORY SUMMARY OF CHEMICAL TESTING

Soil Sample	SDi-4556	SDi-4807	SDi-4808	Dark D.G.	Light D.G.
% Moisture	6.7	10.7	16.3	4.8	10.3
pH	6.8	8.3	6.2	6.5	6.8
Phosphorus*	2.68	1.78	3.54	0.10	0.92
Calcium*	7.19	44.25	4.38	6.72	5.80
Magnesium*	1.54	3.09	1.20	2.56	3.75
Sodium*	3.27	4.46	2.92	16.64	21.48
Potassium*	8.18	18.18	12.78	1.28	1.26

*Parts per million of dry midden or decomposed granite (D.G.) soil.

TABLE 2

DENSITY-MOISTURE TEST RESULTS

Before Placement and After Retrieval of Artifacts

	Density, lbs/ft^3	% Moisture
Before Artifact Placement	103.6	10.0
After Artifact Retrieval	109.8	10.0

TABLE 3

OBJECTS PLACED WITHIN THE EXCAVATION UNITS

Locus A - Level 0-10 cm

Number	Provenience
12	Small unmodified granite cobbles
3	Artist's charcoal sticks
2	Obsidian flakes
1	Obsidian projectile point
3	Complete _Olivella_ shells (beads)
2	_Olivella_ disc beads
3	Pieces of cut and formed abalone (_Haliotis_ sp.) shell
8	Unmodified invertebrate shells
1	"Sand Dollar" fragment

Locus A - Level 10-20 cm

1	Granite Mano
1	Arrow shaft straightener
3	Artist's charcoal sticks
1	Basalt biface
1	Chert core fragment
10	Unmodified invertebrate shells
1	"Sand Dollar" fragment
11	Fragments of historic faunal material

TABLE 3 (Continued)

Locus A - Level 20-30 cm

Number	Provenience
4	Unmodified invertebrate shells
1	*Olivella* disc bead
3	Artist's charcoal sticks
4	Unmodified obsidian flakes
2	Obsidian projectile points/bifaces
1	Centrally-notched obsidian biface
1	Large biface of grey obsidian
15	Fragments of historic faunal material
13	Granite cobbles

Locus B - Level 0-10 cm

9	Unmodified invertebrate shells
9	Fragments of historic faunal material
1	A sedimentary stone with invertebrate shell fossils
3	Artist's charcoal sticks
1	Obsidian biface
1	Obsidian projectile point
3	Unmodified obsidian flakes
2	Chert core fragments

TABLE 3 (Continued)

Locus B - Level 10-20 cm

Number	Provenience
11	Granite cobbles
3	Artist's charcoal sticks
12	Unmodified invertebrate shells
9	Fragments of historic faunal material

Locus B - Level 20-30 cm

1	Mexican ceramic pot (complete)
1	Mano and a metate (associated)
10	Unmodified invertebrate shells
3	Artist's charcoal sticks

TABLE 4

FIELD EXPERIMENT SUMMARY OF CHEMICAL TESTING

	Soil Covering Artifacts						Decomposed Granite		
Sampled During	Artifact Placement			Artifact Retrieval			Artifact Placement		
Sample No.	1	2	Avg.	1	2	Avg.	1	2	Avg.
pH	7.0	6.9	7.0	7.6	7.1	7.4	6.9	7.5	7.2
Phosphorus*	2.15	2.6	2.38	.72	1.0	.86	2.05	.5	1.28
Calcium*	21	24	22.5	11	11	11	2.1	3.2	2.6
Magnesium*	6.6	5.8	6.2	3.2	3.2	3.2	2.0	1.1	1.6
Sodium*	20	29	24.5	28	31	29.5	40	41	40.5
Potassium*	18	22	20	9.0	9.4	9.2	1.6	1.7	1.6
Zinc*	.12	.33	.22	.15	.06	.10	--	.03	.03

*Parts per million of dry soil

X. FIGURES

IN SAN DIEGO COUNTY ABOUT 9 MILES NORTH OF ESCONDIDO
FROM 1.5 MILES SOUTH OF LILAC ROAD TO 0.3 MILE SOUTH
OF ROUTE 76

11-S.D-15-R42.8/R46.3

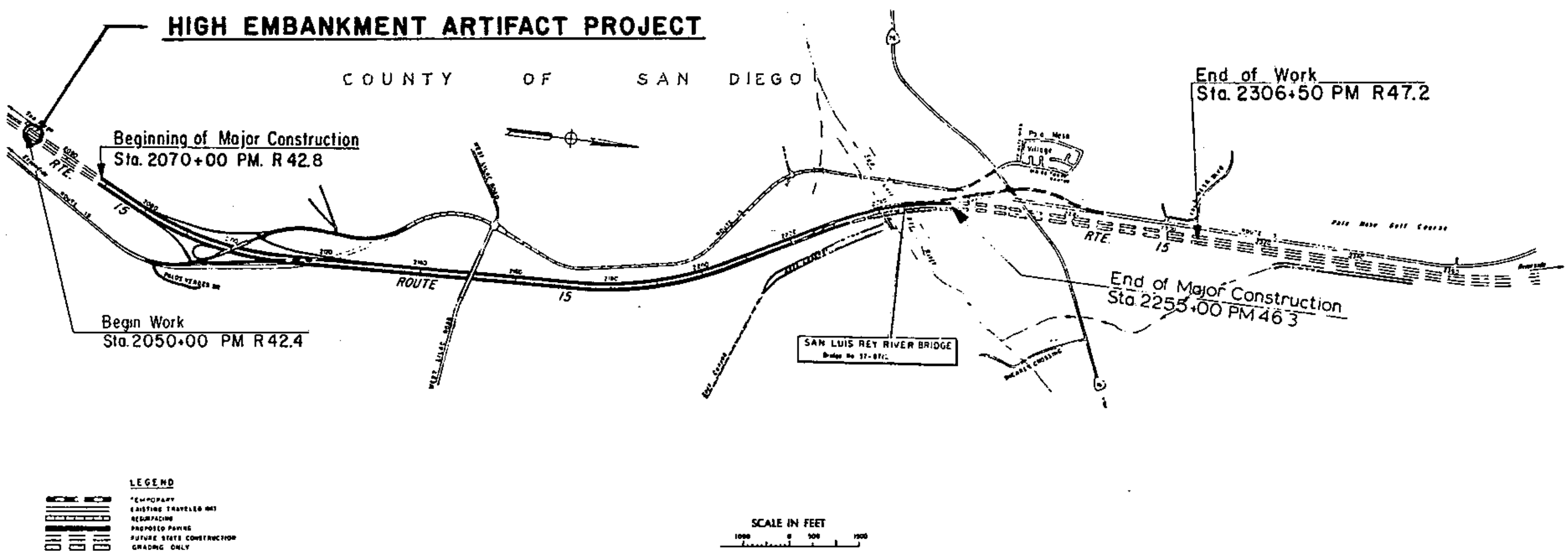


FIGURE 1. MAP OF HIGH EMBANKMENT ARTIFACT PROJECT INDICATING LOCATION OF RESEARCH SITE.

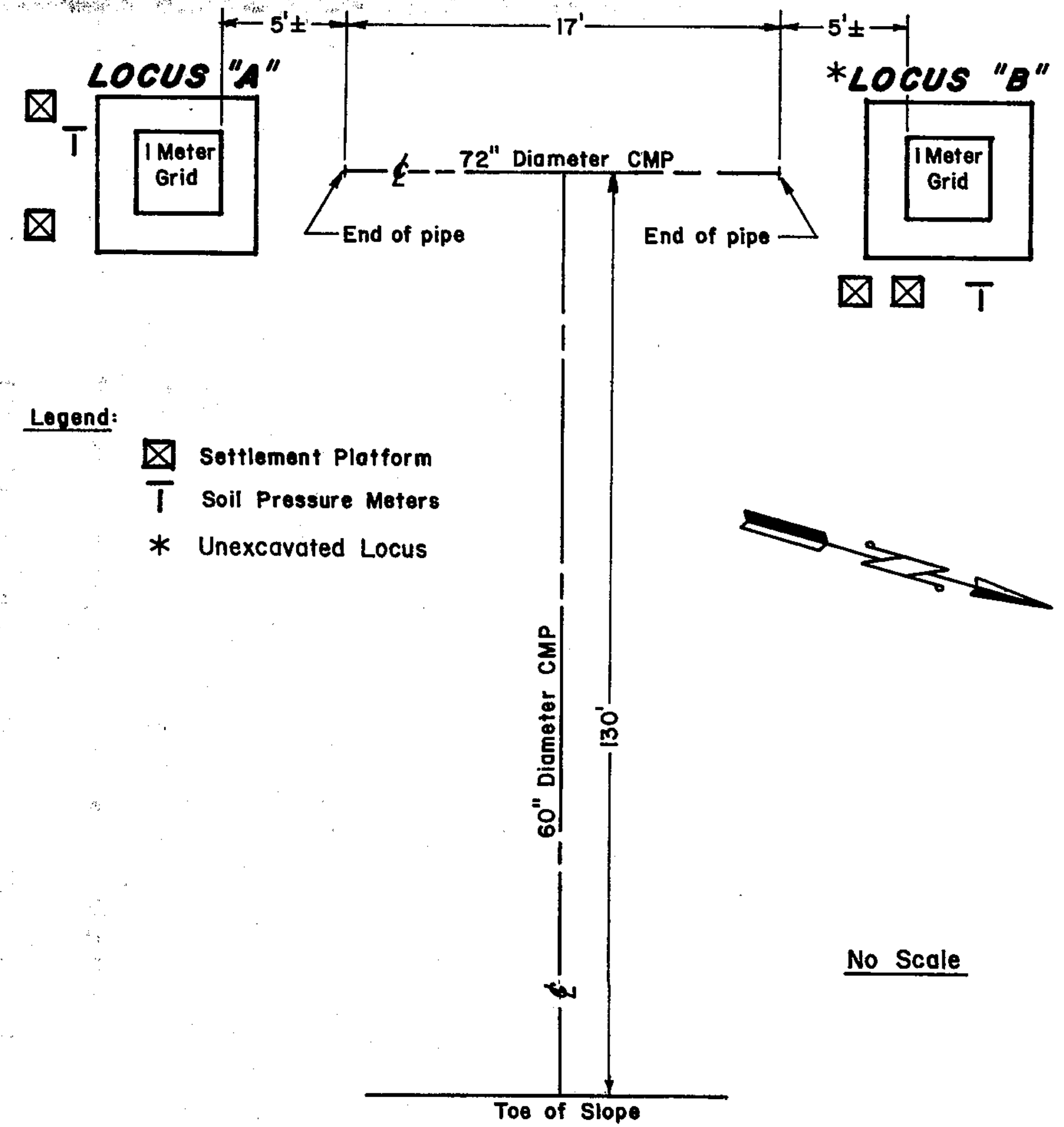


FIGURE 2. SKETCH SHOWING ARTIFACT SITES AND ACCESS PIPES

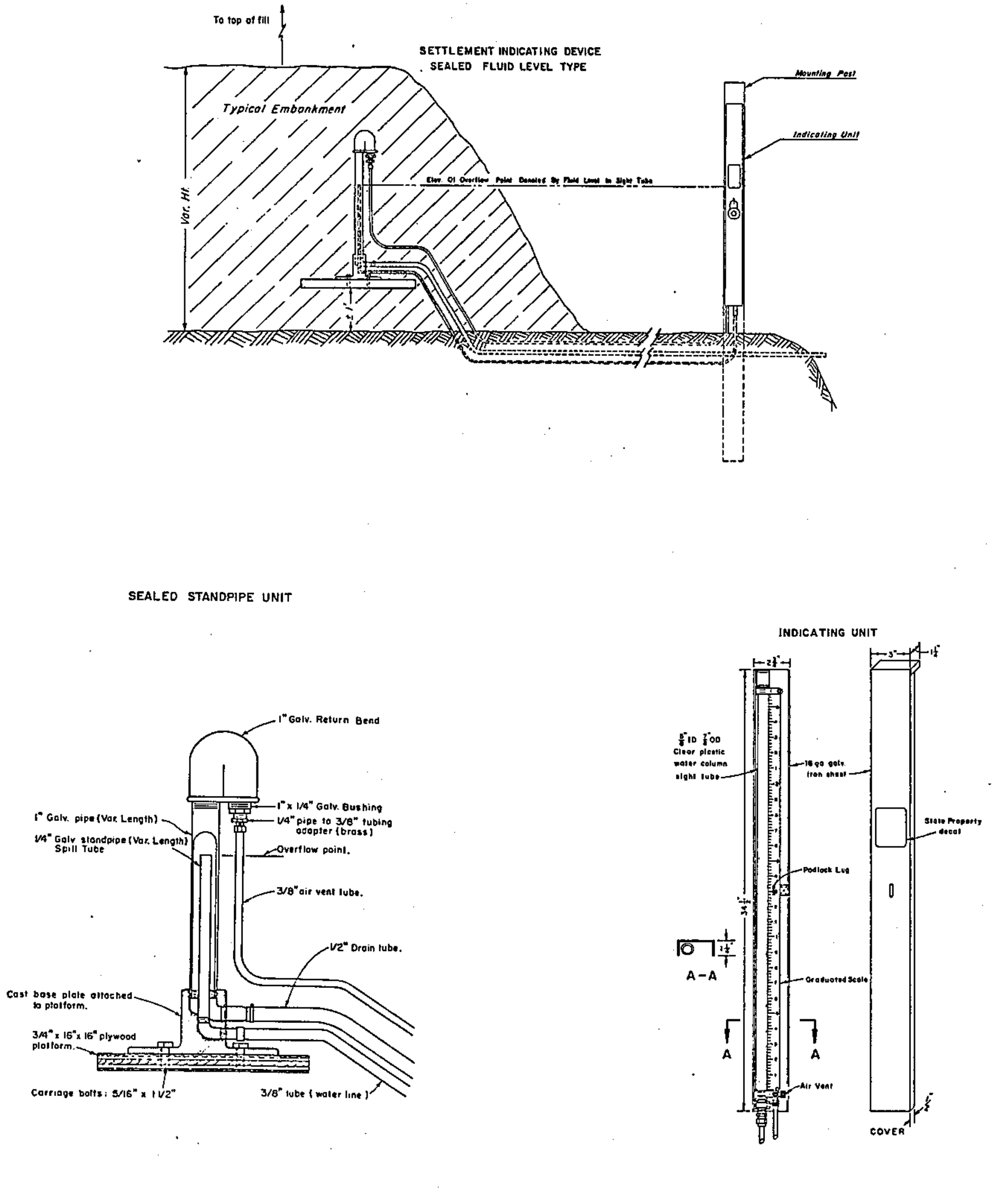


FIGURE 3. SETTLEMENT PLATFORM

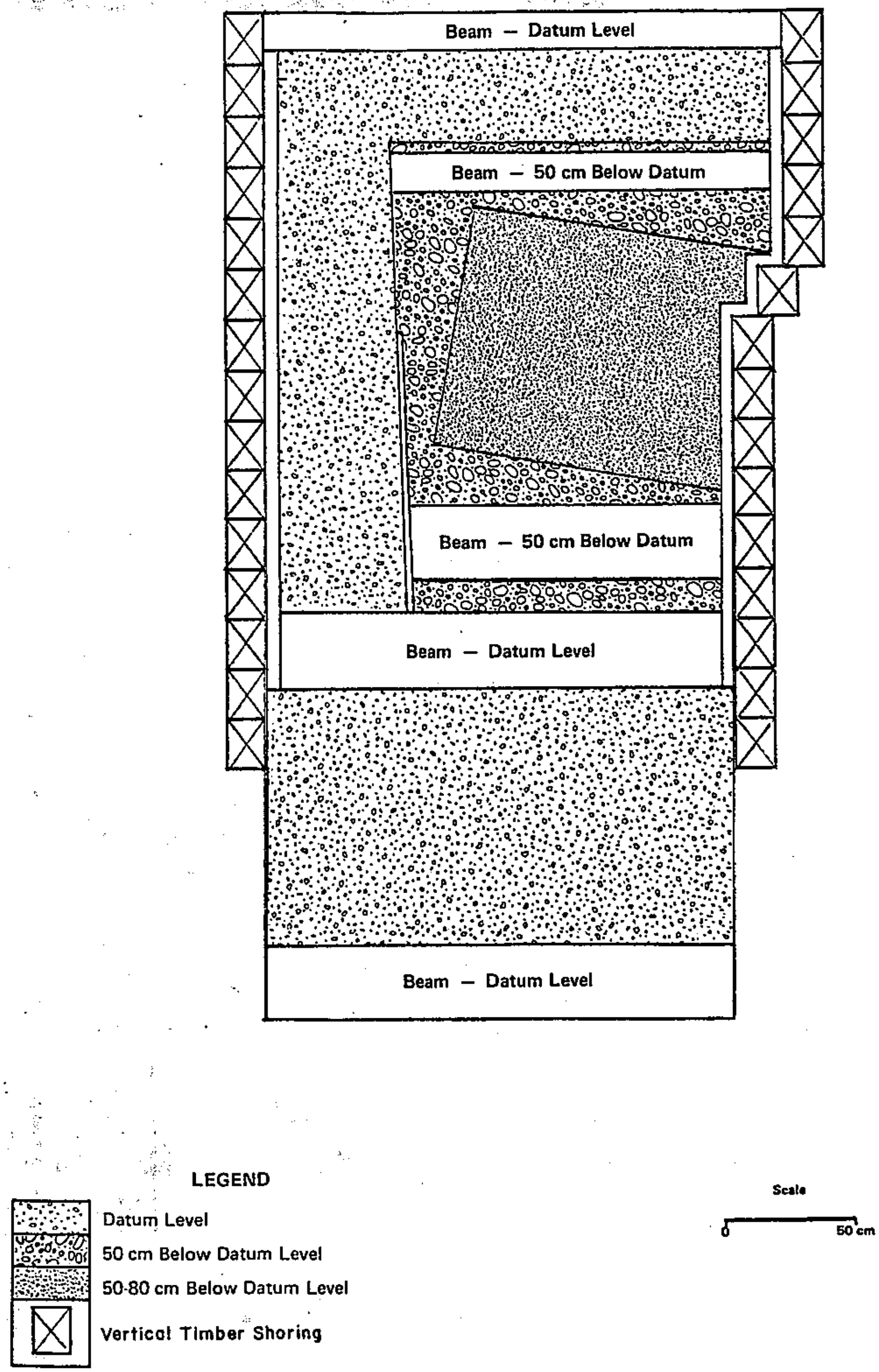


FIGURE 4. LOCUS A FLOOR PLAN

XI. PHOTOGRAPHS

PHOTO 1 - Artifact Access Pipe

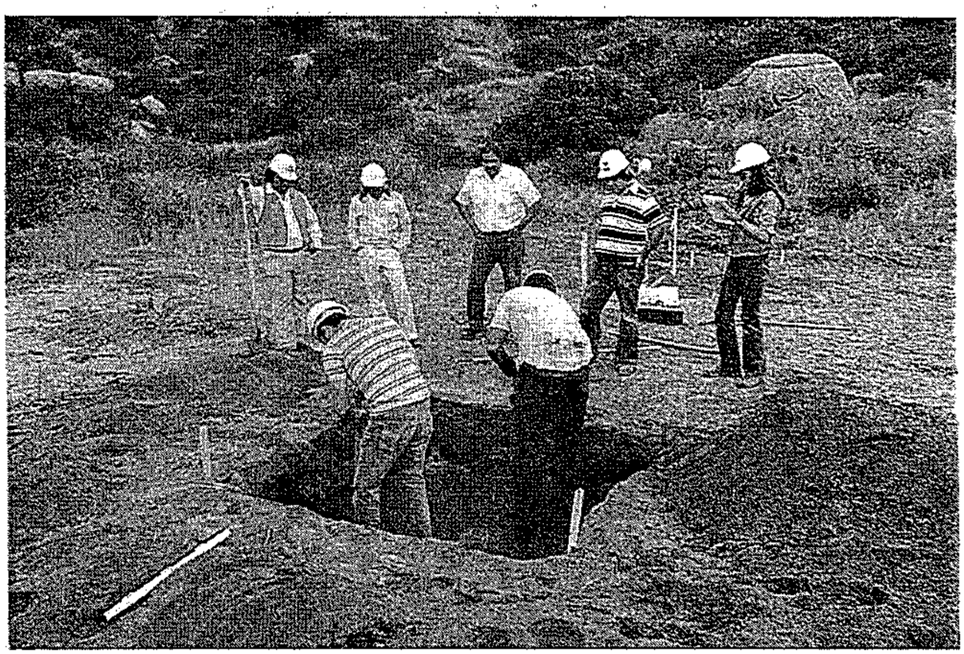


PHOTO 2 - Excavated Test Site

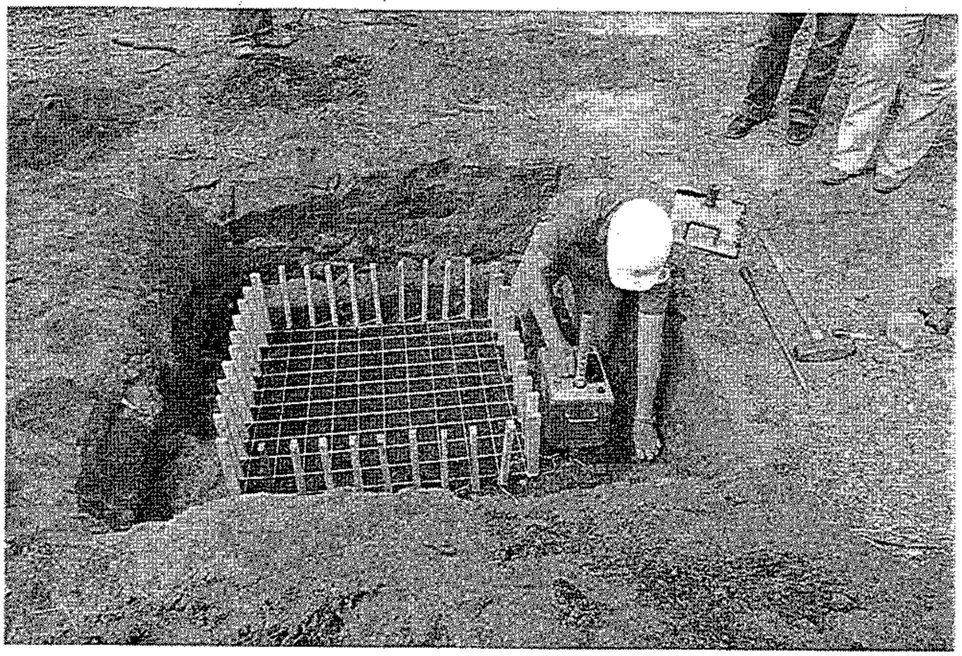


PHOTO 3 - Nuclear Soil Moisture-Density Test

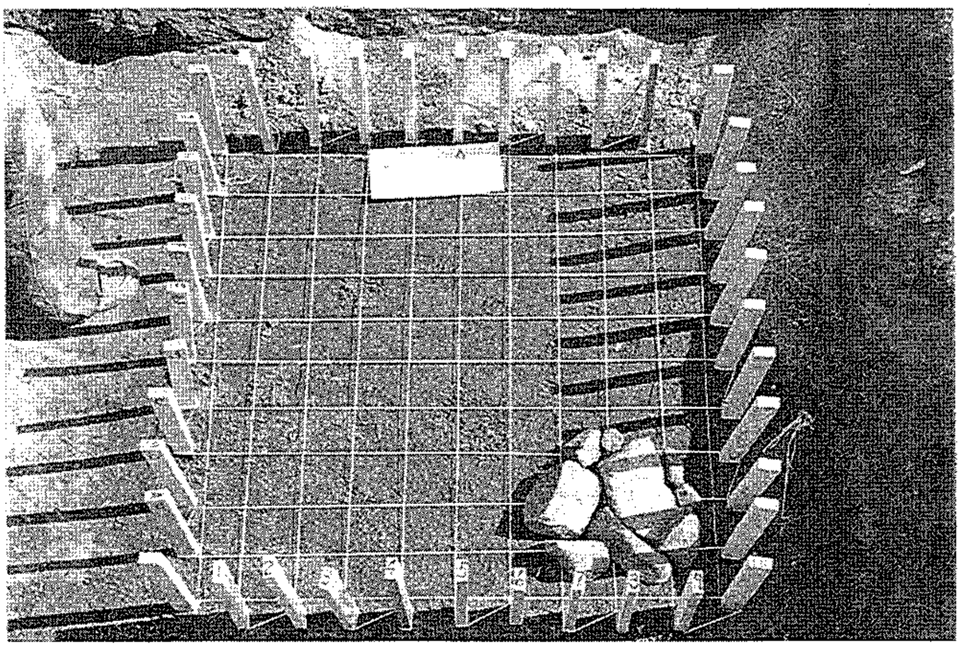


PHOTO 4 - Grid System

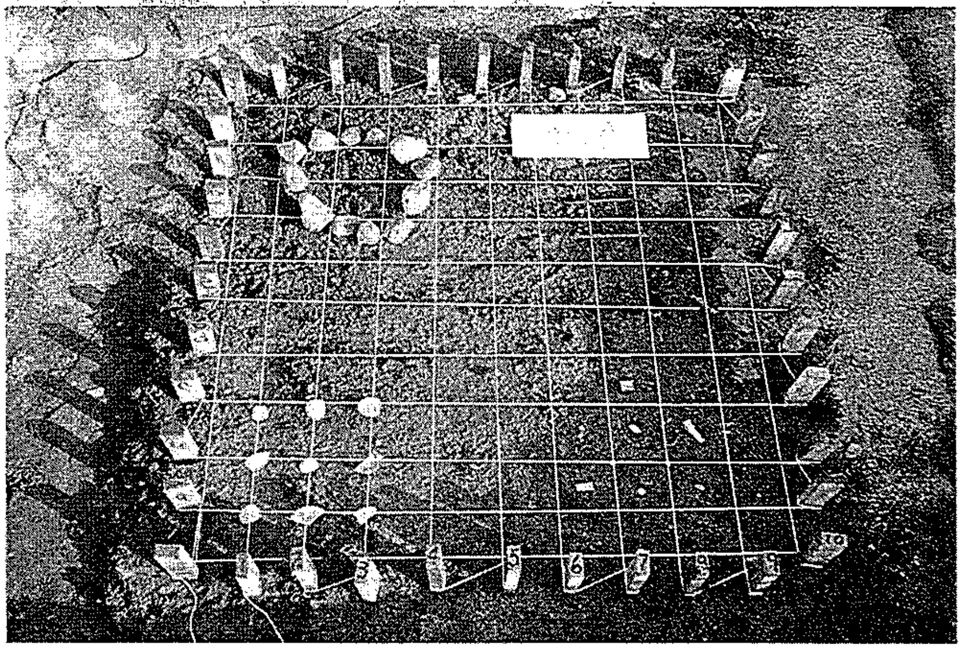


PHOTO 5 - Locus A 0-10 cm
Layer of Artifacts

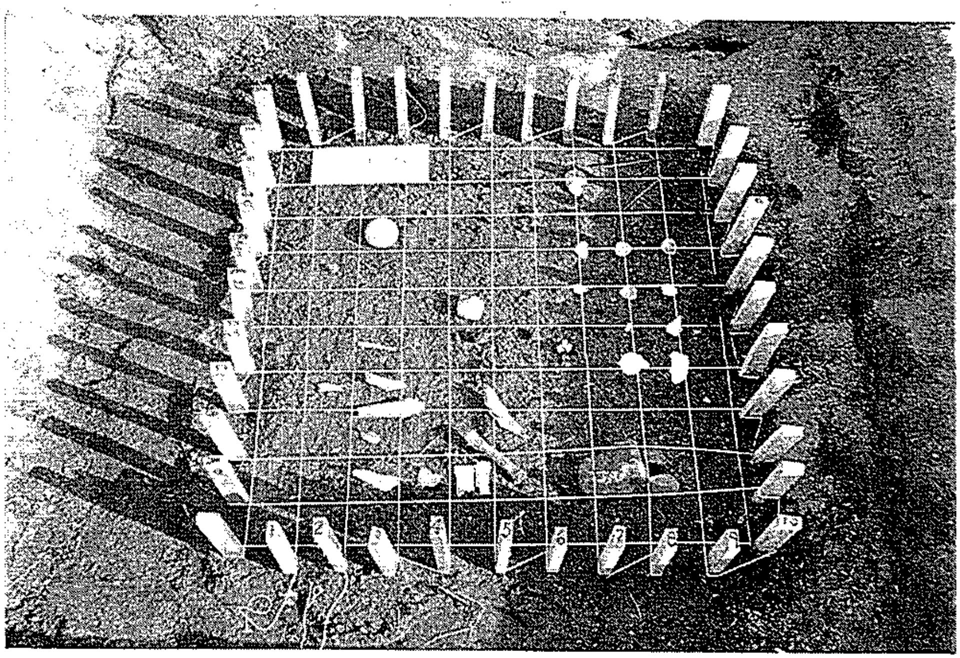


PHOTO 6 - Locus A 10-20 cm
Layer of Artifacts

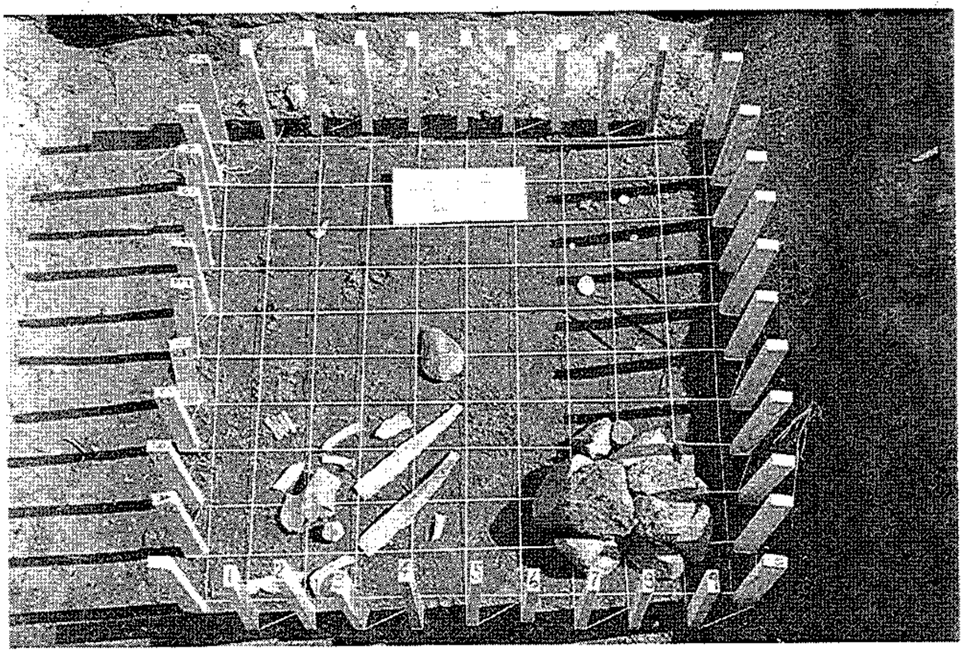


PHOTO 7 - Locus A 20-30 cm
Layer of Artifacts

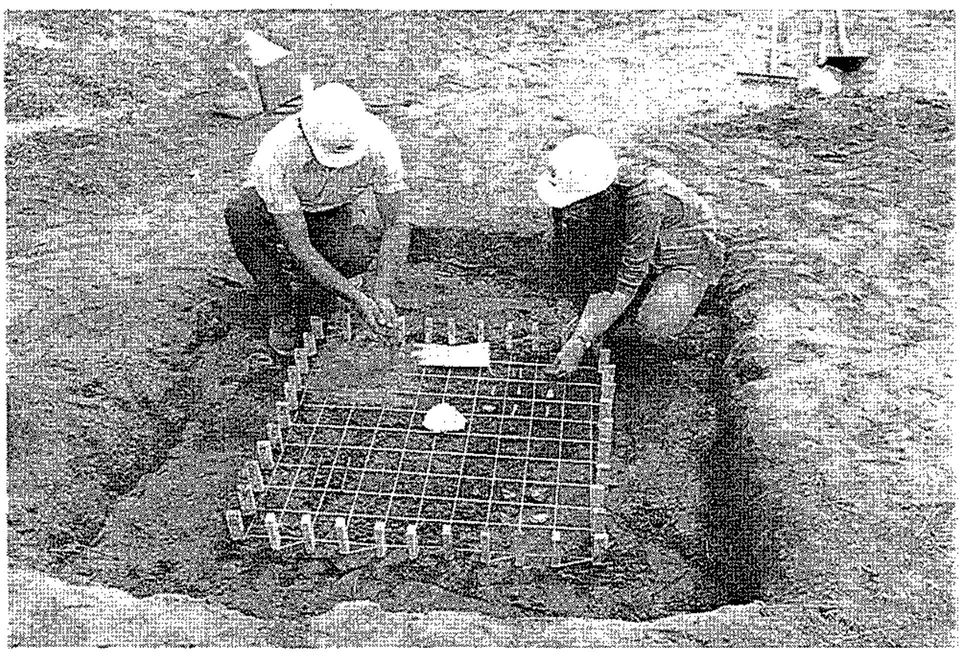


PHOTO 8 - Covering Artifacts by Hand

PHOTO 9 - Adding Water to the Midden Soil to Insure Uniform Compaction

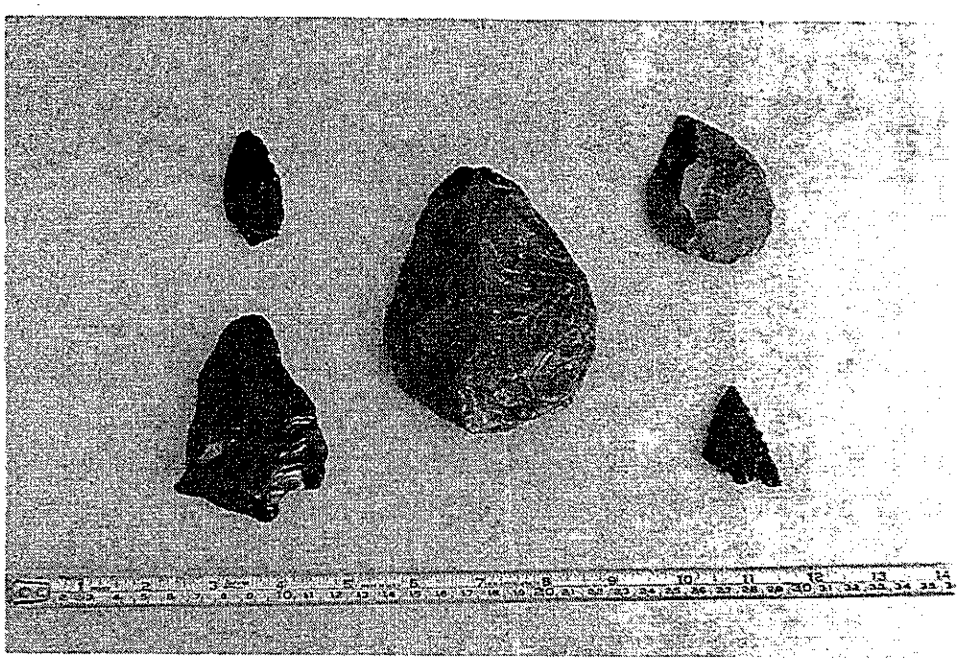


PHOTO 10 - Artifacts Prior to Placement
Bifaces and Projectile Points
Top Left: Black Obsidian Biface
Top Right: Fine Grey Basalt Biface
Middle: Large Grey Obsidian Biface
Bottom Left: Black Obsidian Biface
Bottom Right: Mahogany Obsidian Projectile Point

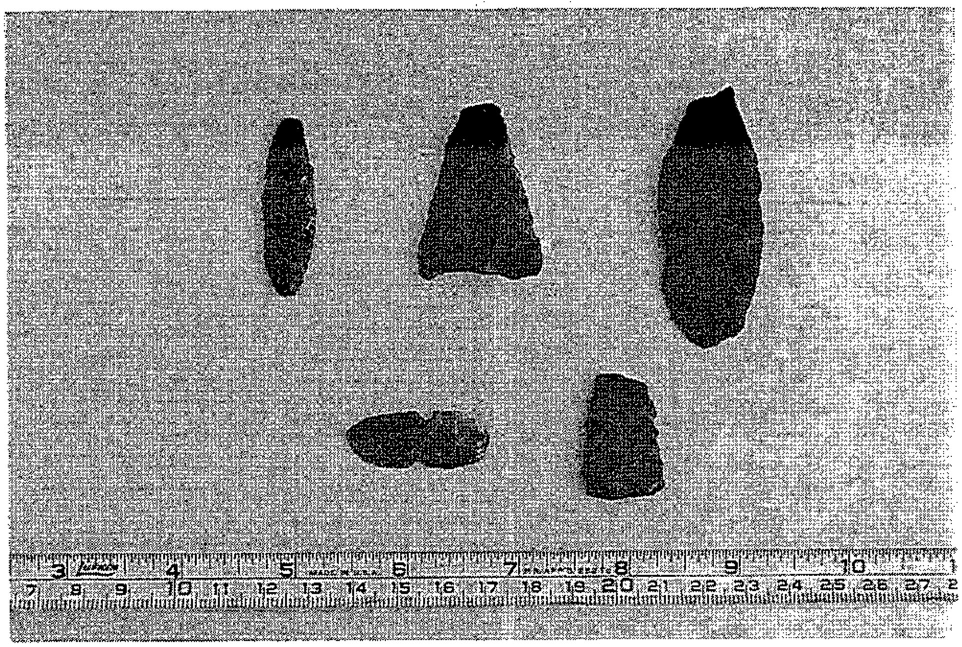


PHOTO 11- Artifacts Prior to Placement
Bifaces
Top Left: Mahogany Obsidian Biface
Top Center: Mahogany Obsidian Biface
Top Right: Black Obsidian Biface
Bottom Left: Centrally-notched Translucent-Black Obsidian Biface
Bottom Right: Black Obsidian Biface

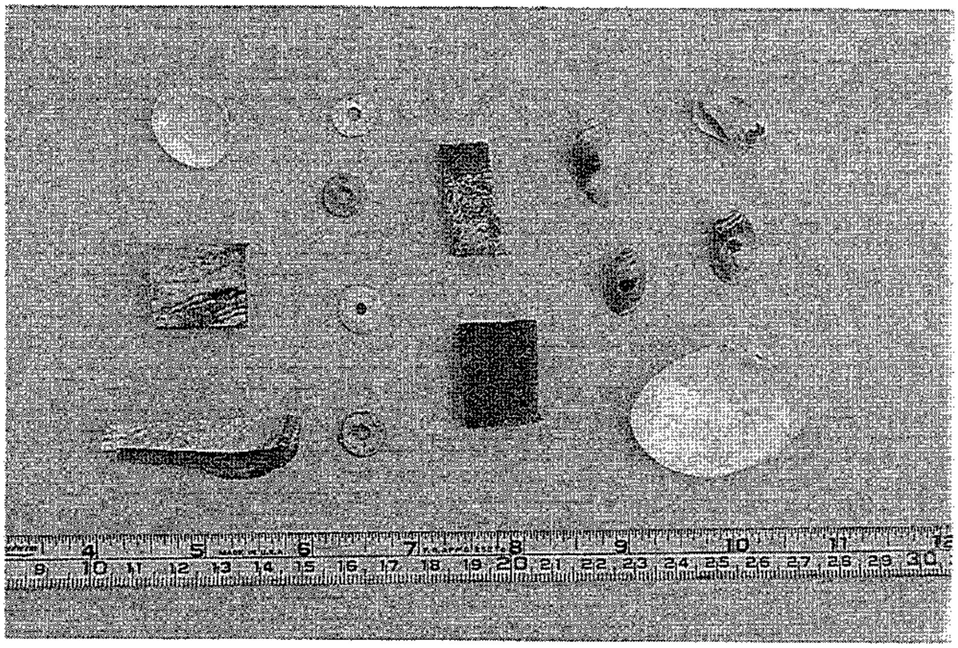


PHOTO 12 - Artifacts Prior to Placement
Shell Beads and Shell Pieces
(Olivella, Clam and Haliotis)

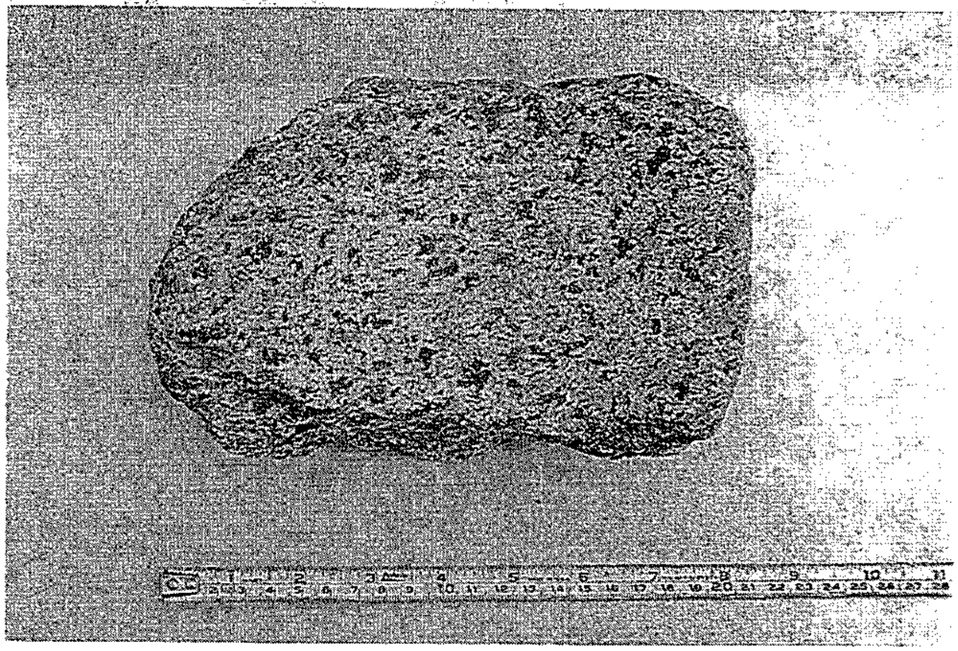


PHOTO 13 - Artifact Prior to Placement
Metate Fragment - Granite

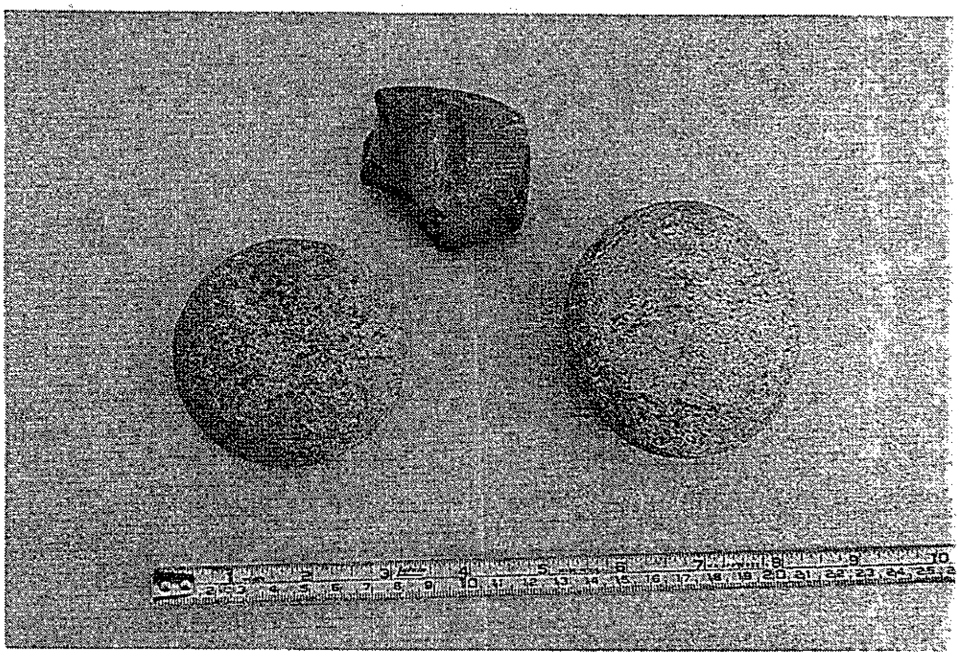


PHOTO 14 - Artifacts Prior to Placement
Manos and Arrow Shaft Straightener
Top: Arrow Shaft Straightener
Bottom Left: Mano - Granite
Bottom Right: Mano - Granite

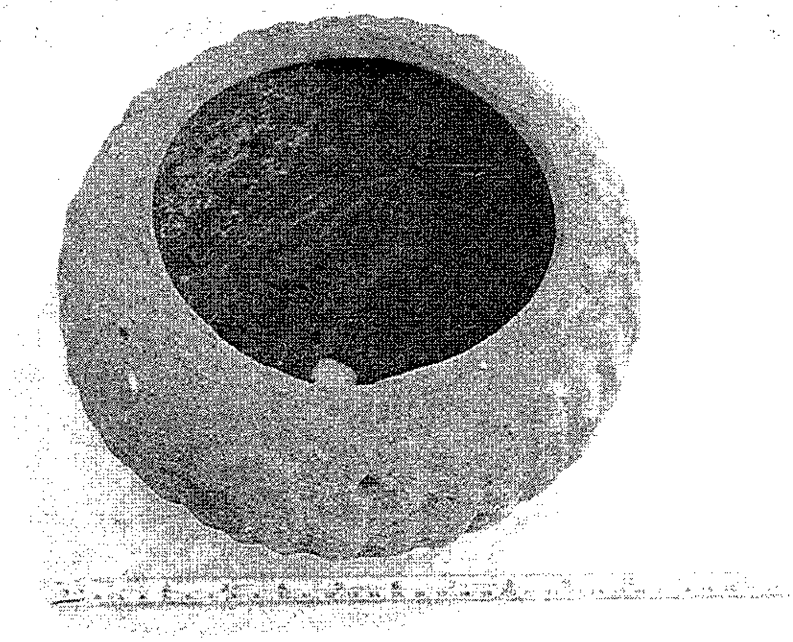


PHOTO 15 - Artifact Prior to Placement
Unglazed Mexican Pot

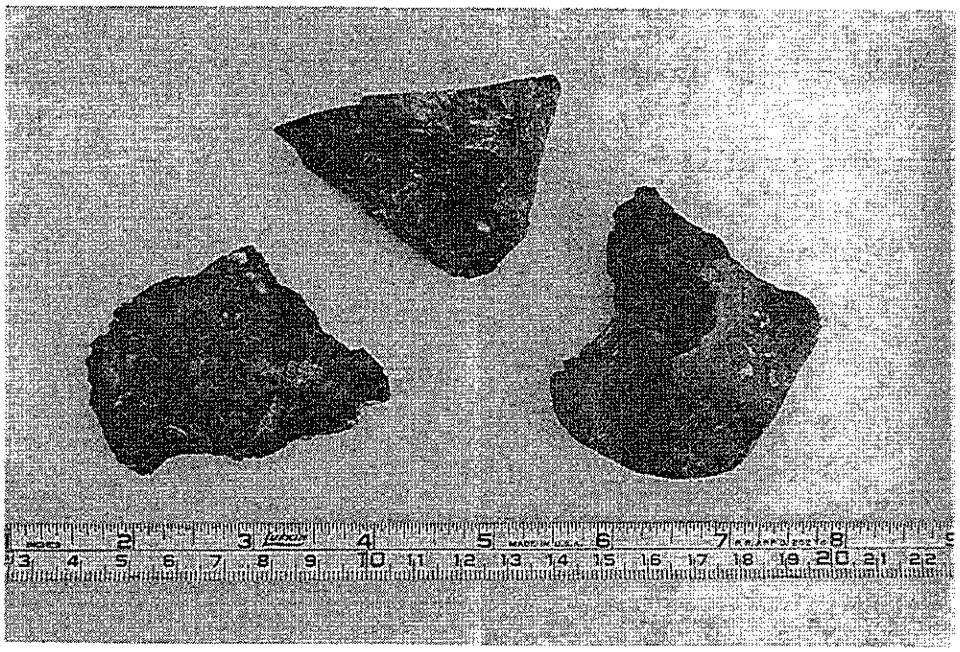


PHOTO 16 - Artifacts Prior to Placement
Unmodified Chert Cobble Fragments

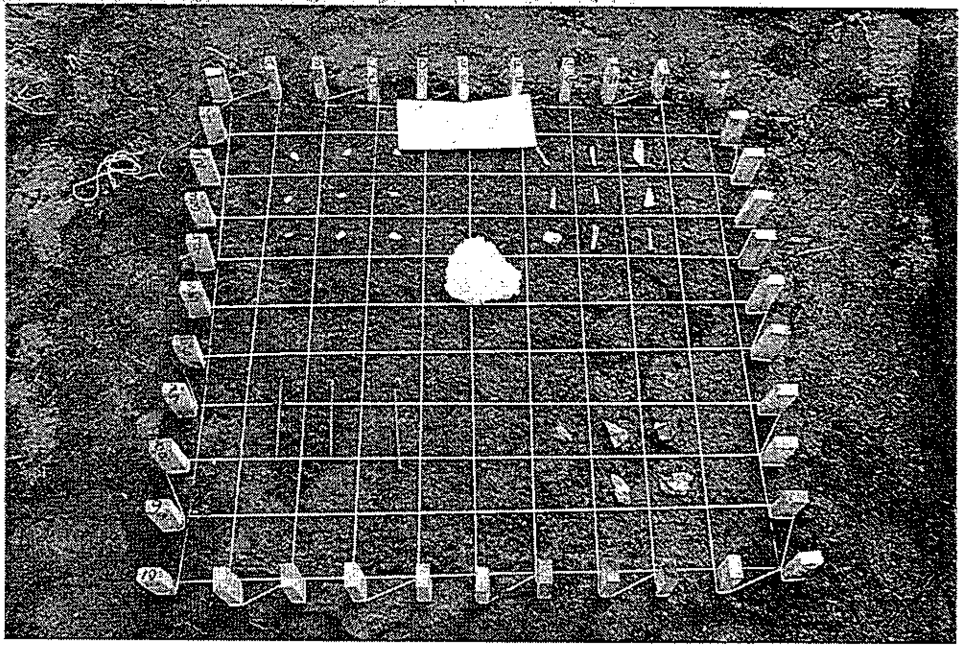


PHOTO 17 - Locus B 0-10 cm
Layer of Artifacts

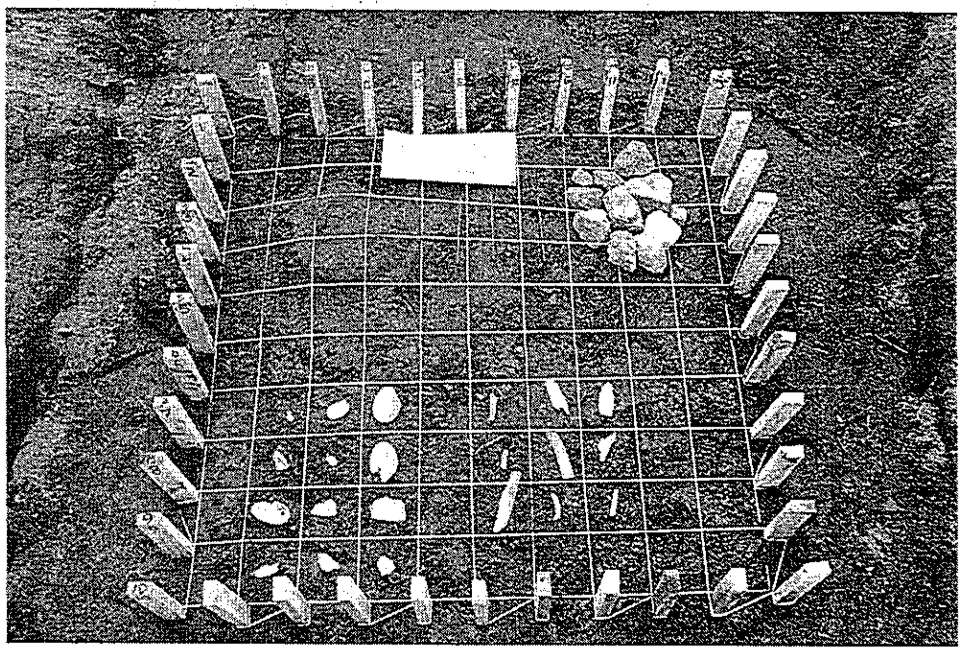


PHOTO 18 - Locus B 10-20 cm
Layer of Artifacts

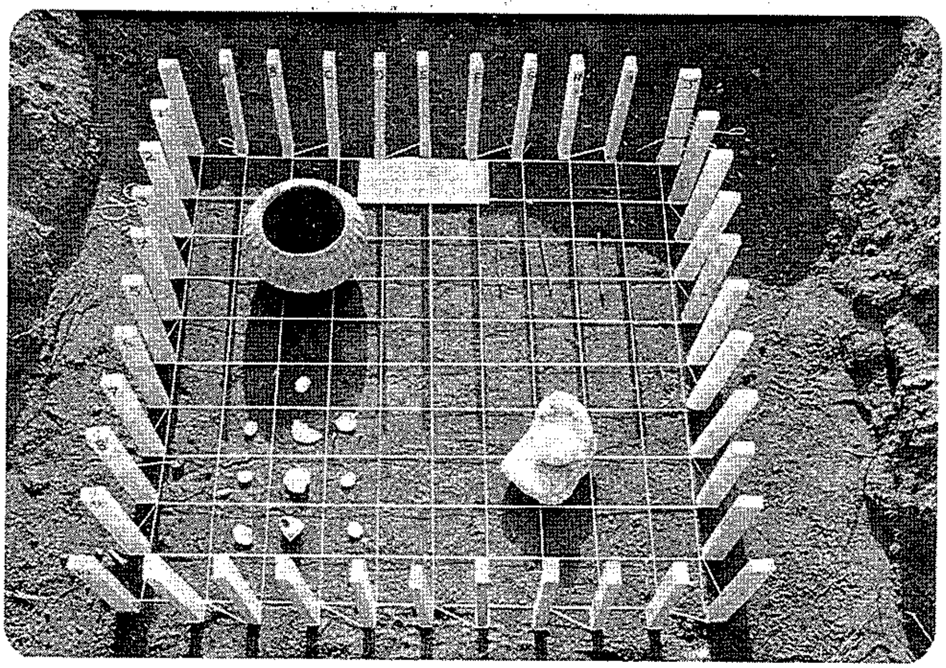


PHOTO 19 - Locus B 20-30 cm
Layer of Artifacts

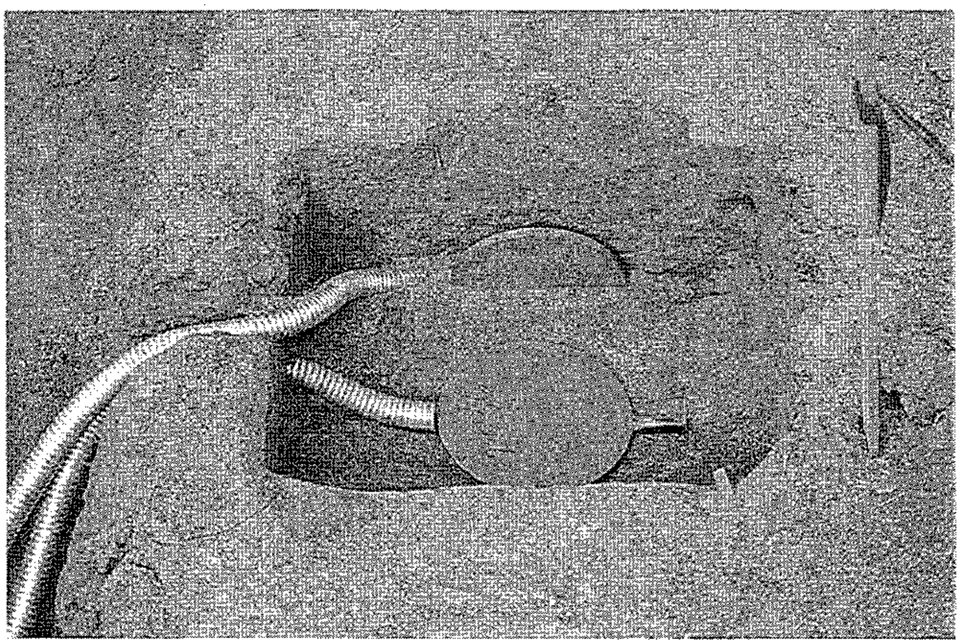


PHOTO 20 - Soil Pressure Meters

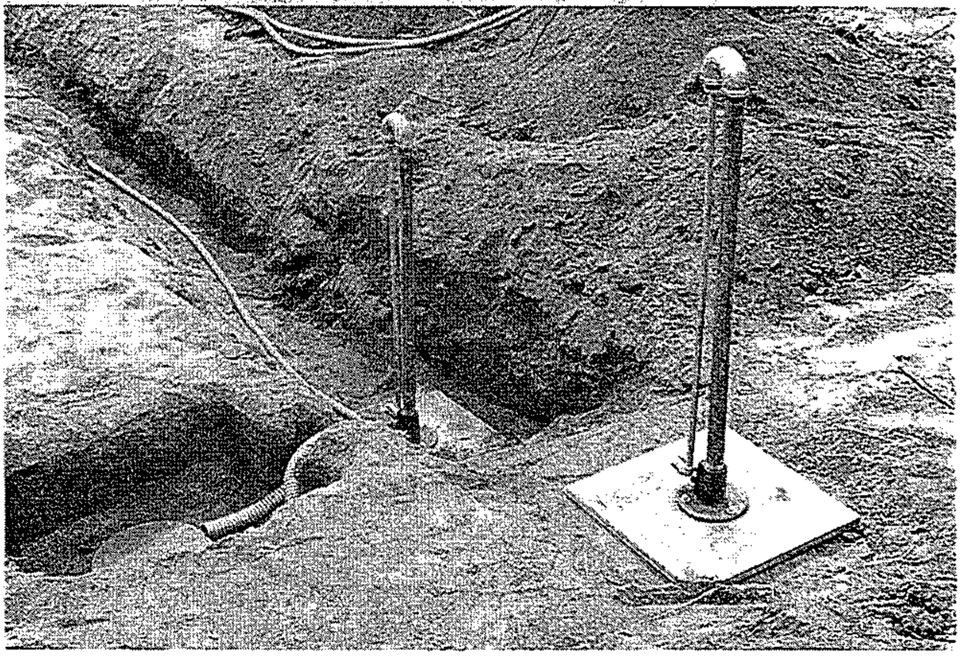


PHOTO 21 - Settlement Platforms

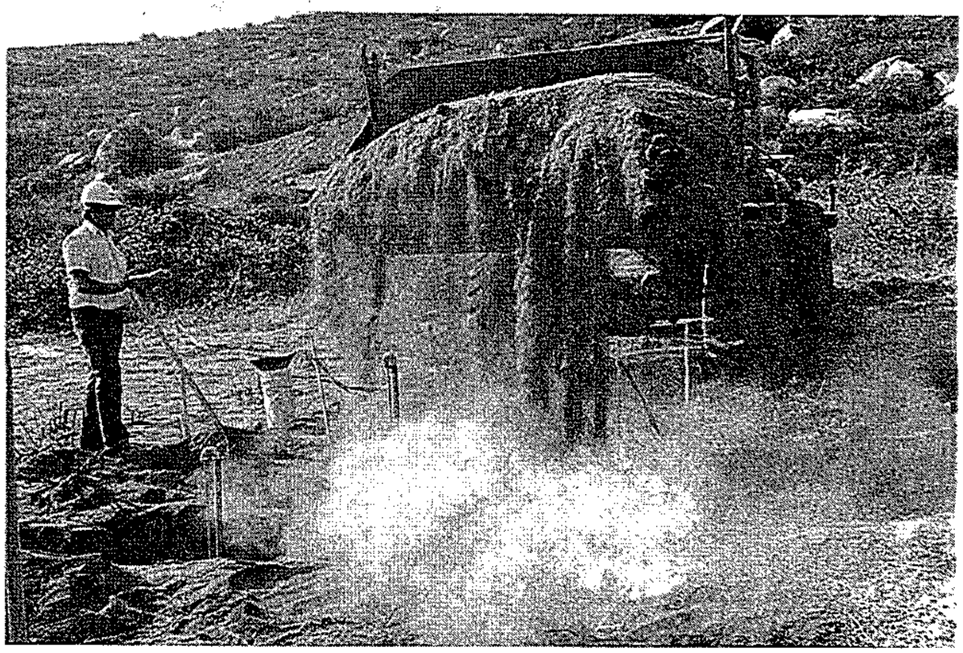


PHOTO 22 - Decomposed Granite Cover Over Test Units

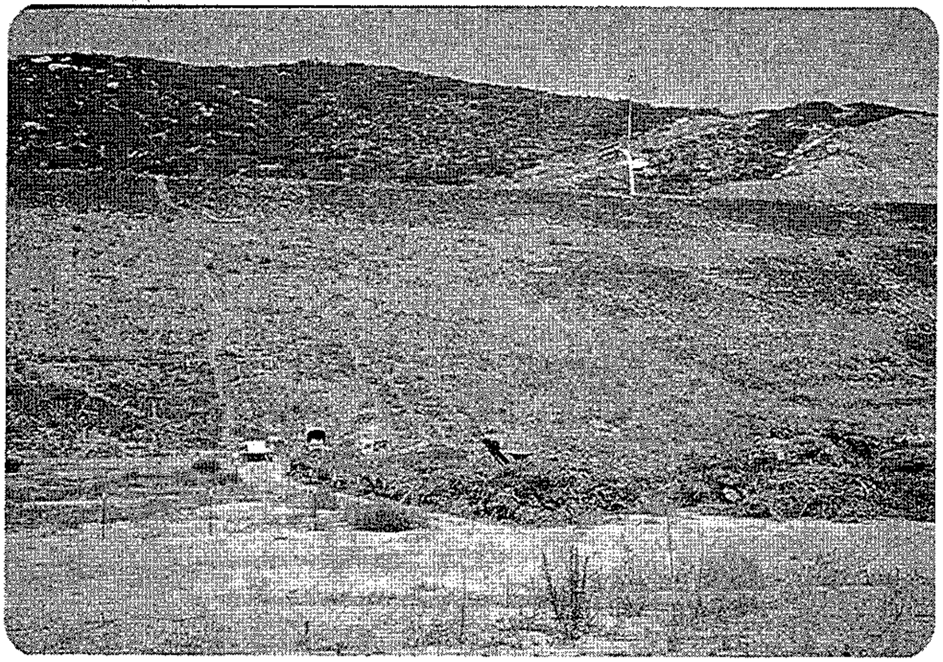


PHOTO 23 - Finished Embankment Over Artifact Test Site (75 feet)

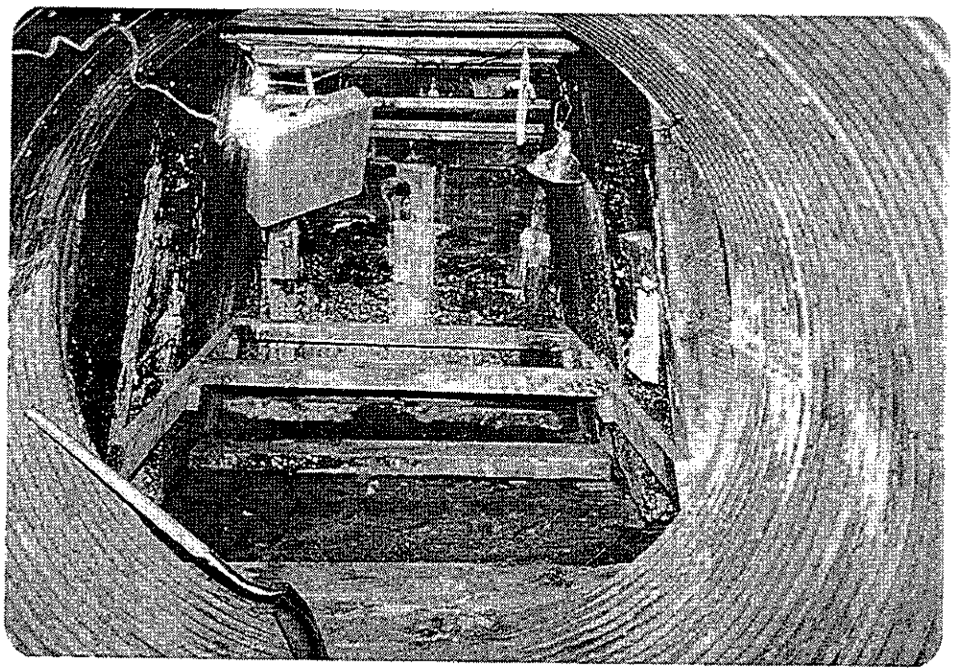


PHOTO 24 - Photographic Lighting Inside Artifact Test Site

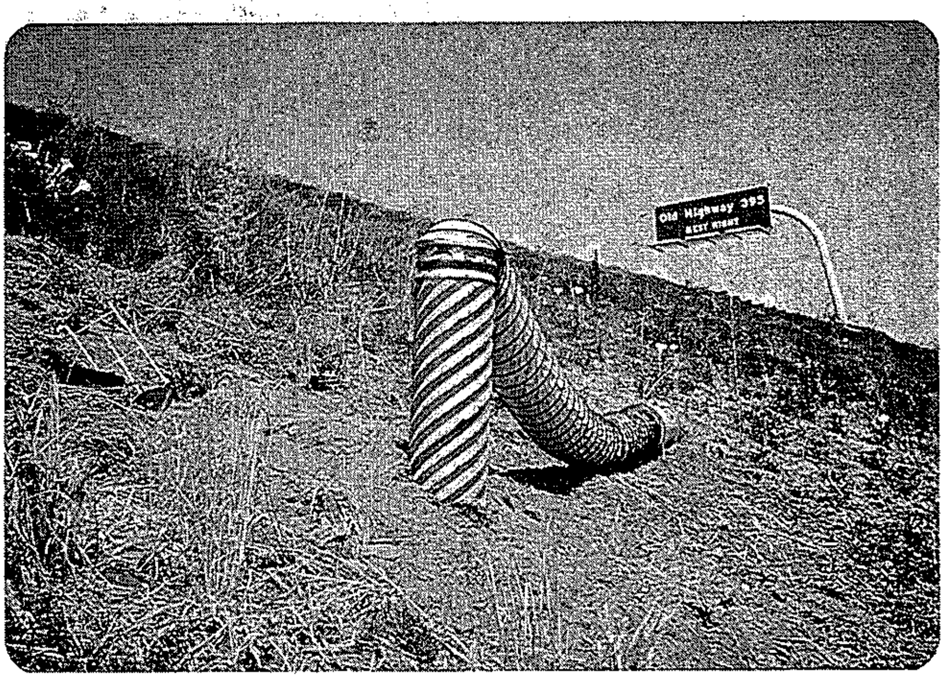


PHOTO 25 - Ventilation Pipe From Access Tunnel

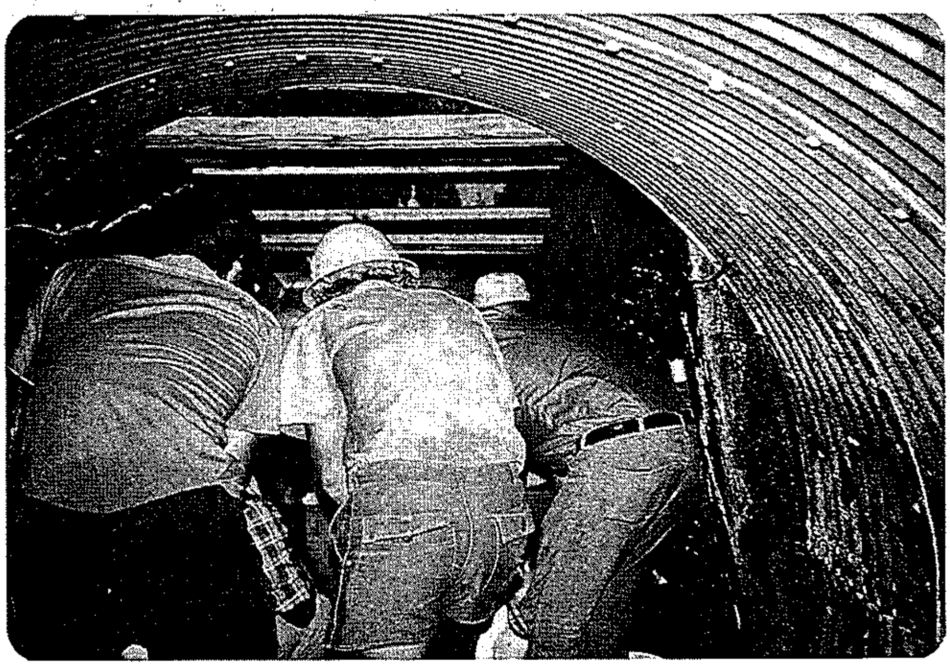


PHOTO 26 - Confined Working Space Inside Access Tunnel

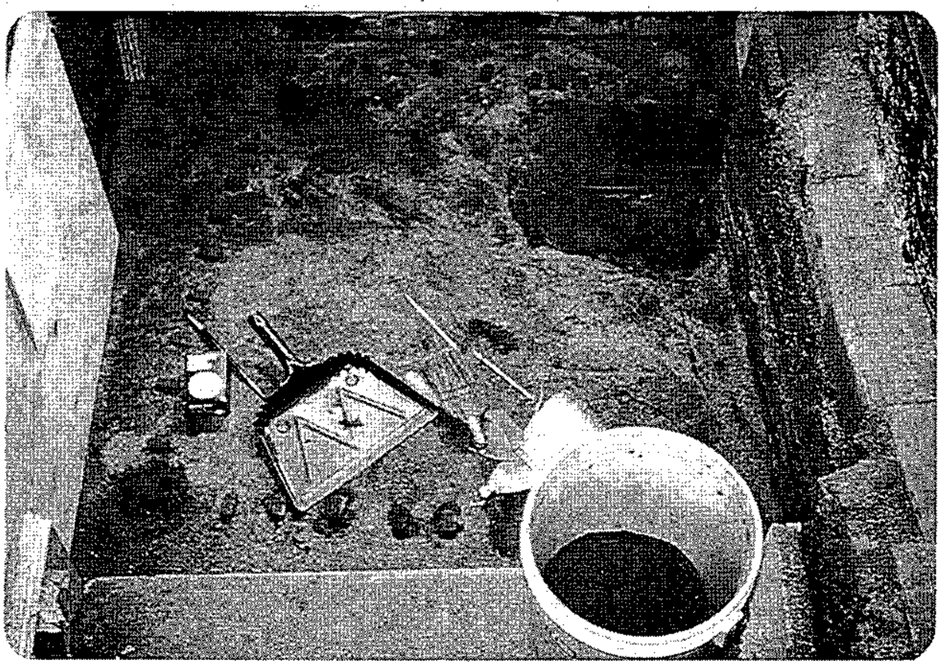


PHOTO 27- Artifact Retrieval Equipment
Used by the Archaeologist

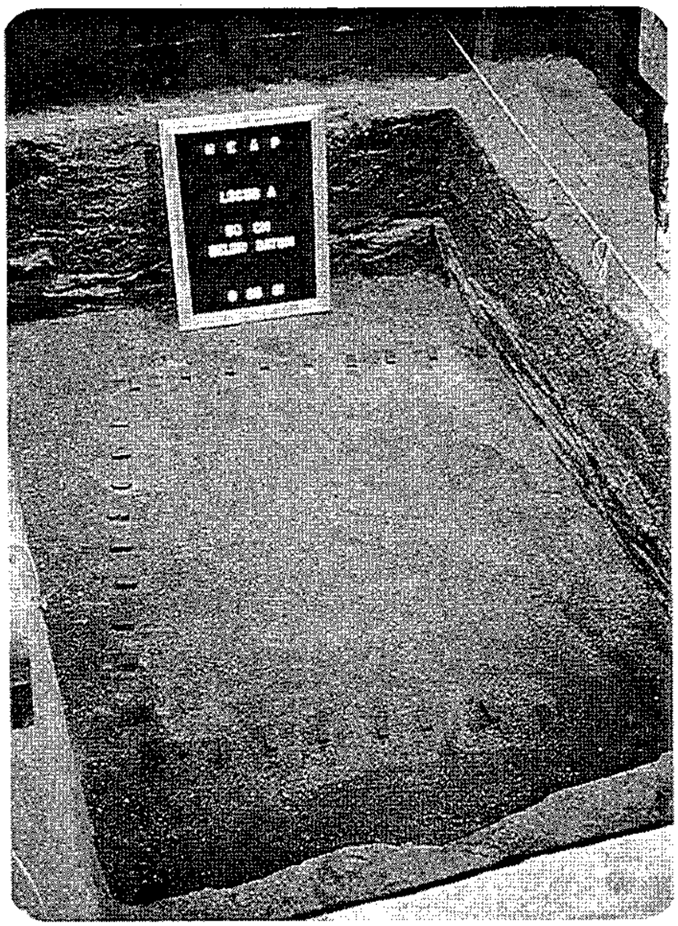
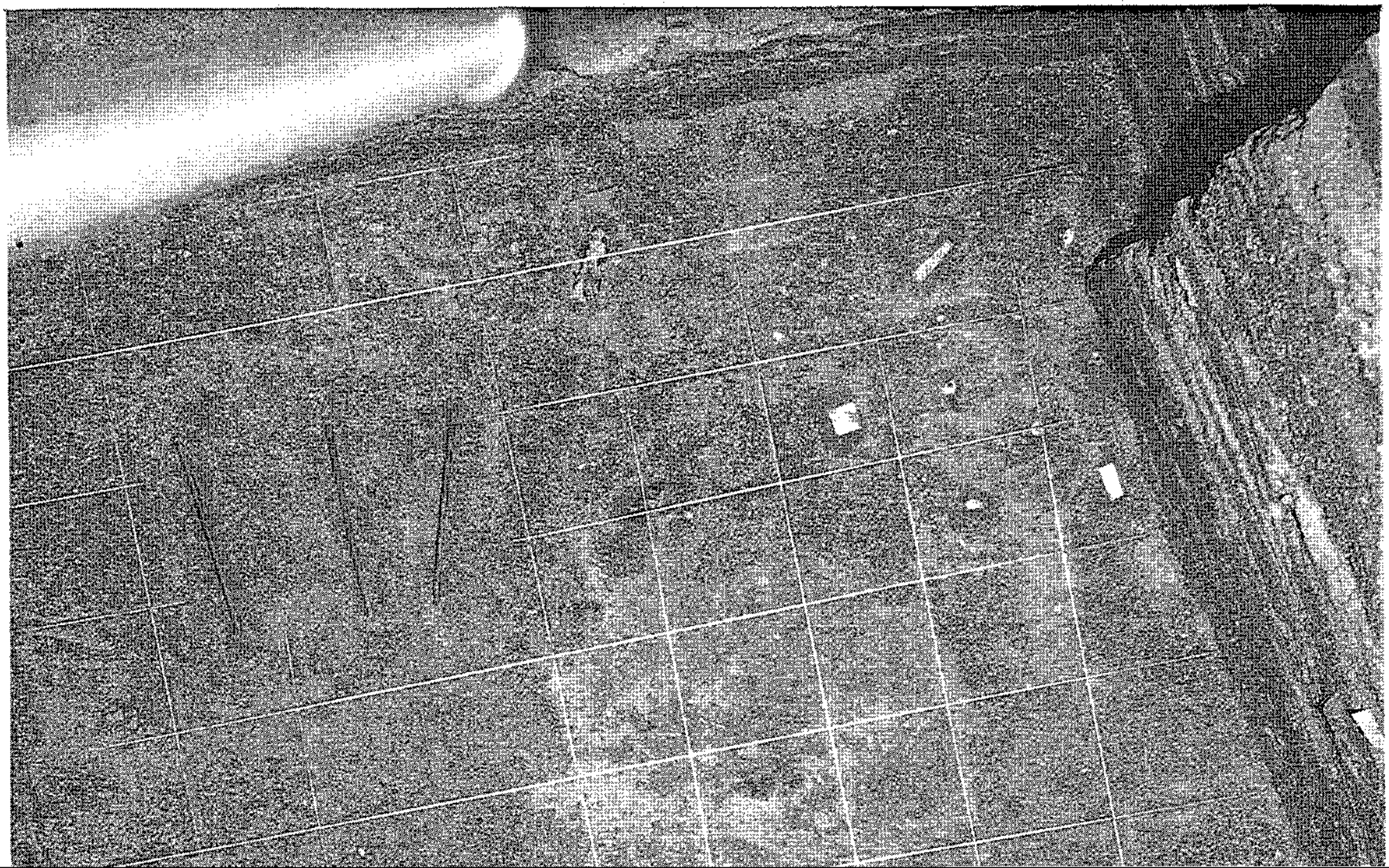


PHOTO 28 - Top of Wooden Stakes Showing
Test Unit Partially Under Shoring

Photo 29 - <u>In Situ</u> Artifacts 0-10 cm Level



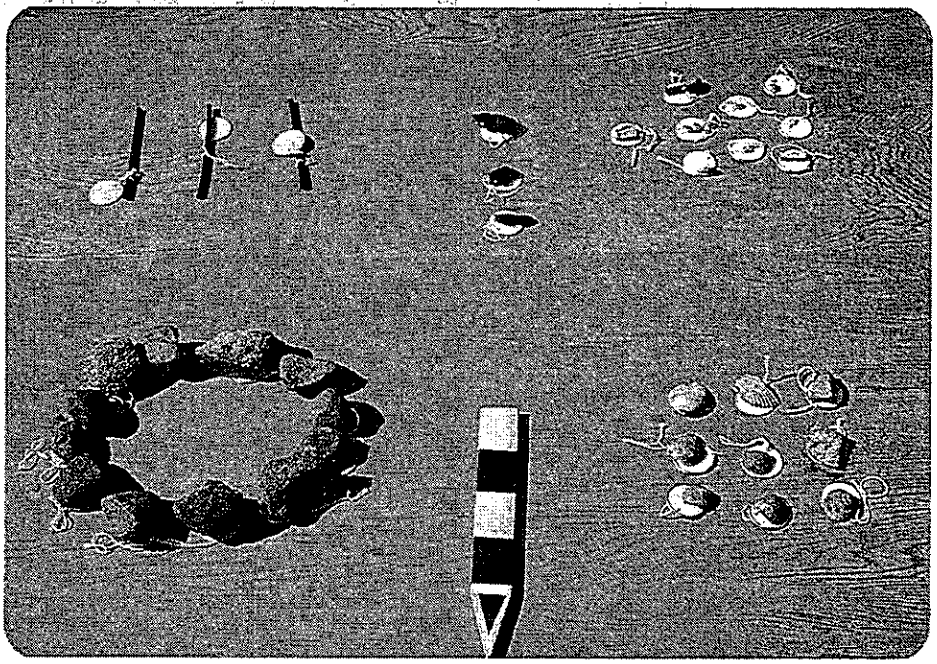


PHOTO 30 - Artifacts From 0-10 cm
Level After Retrieval

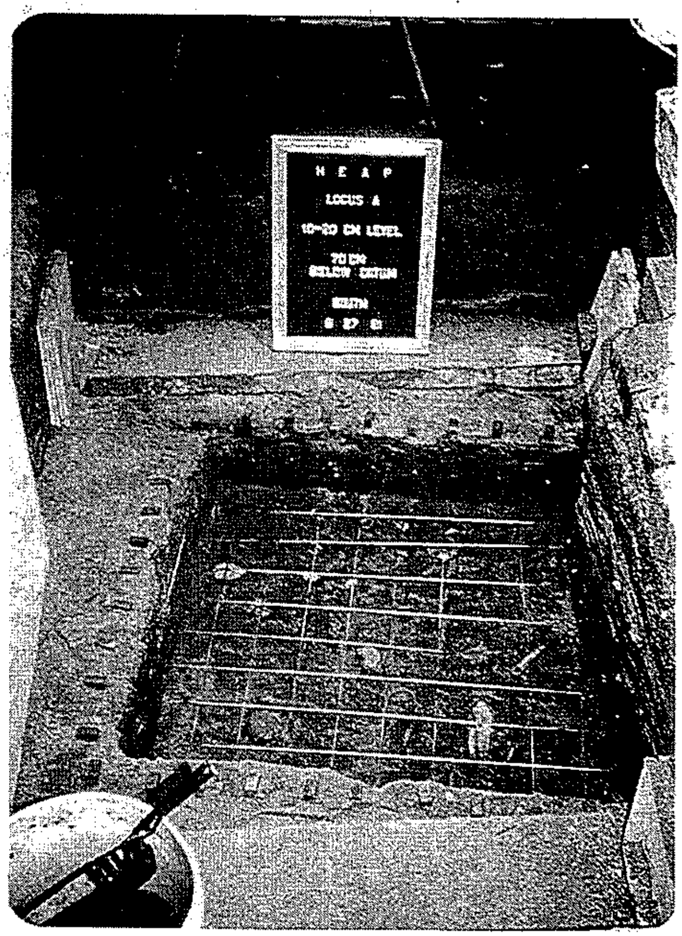


PHOTO 31 - <u>In Situ</u> Artifacts 10-20 cm Level

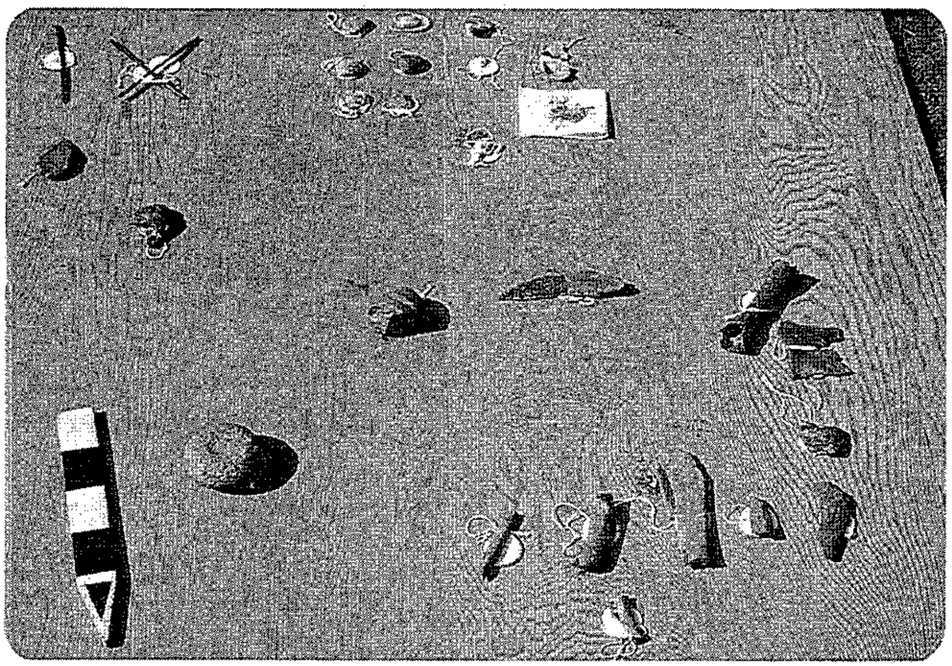


PHOTO 32 - Artifacts From 10-20 cm Level After Retrieval

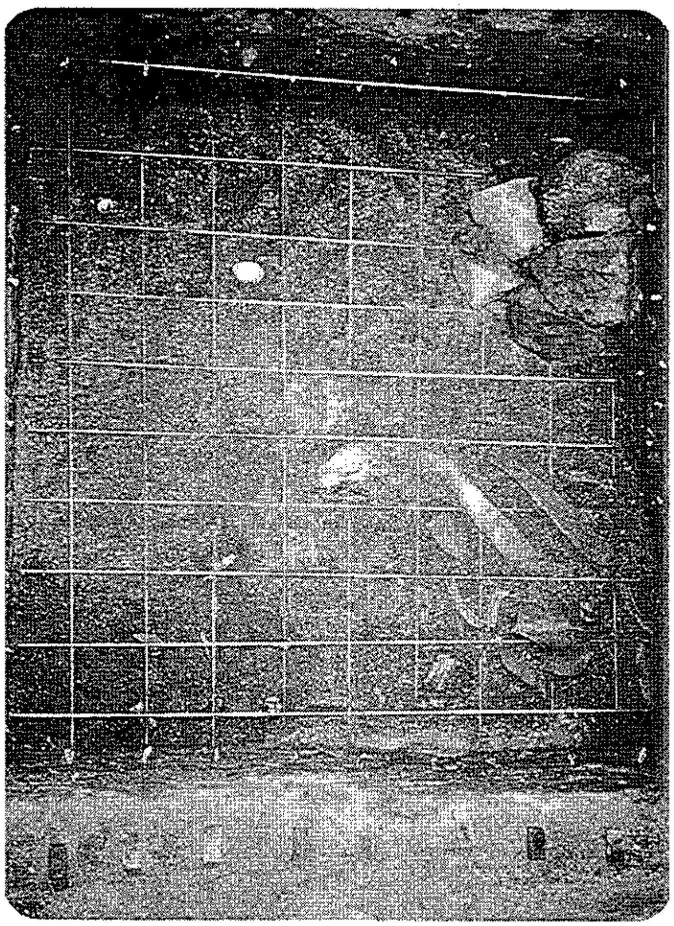


PHOTO 33 - In Situ Artifacts 20-30 cm Level

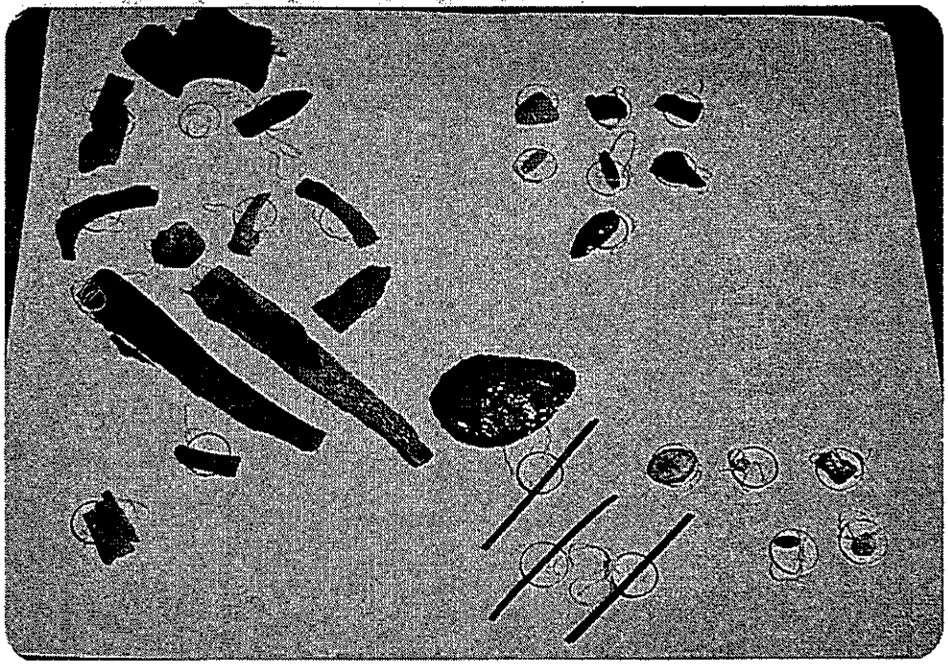


PHOTO 34 - Artifacts From 20-30 cm
Level After Retrieval

PHOTO 35 - <u>In Situ</u> Charcoal Sticks 0-10 cm Level

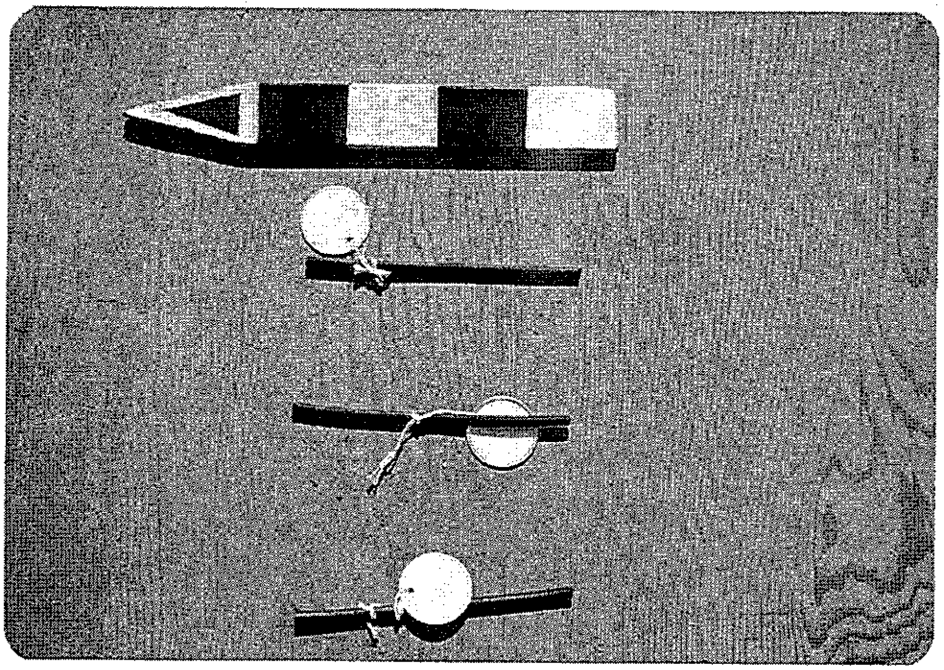


PHOTO 36 - Charcoal Sticks From 0-10 cm
Level After Retrieval

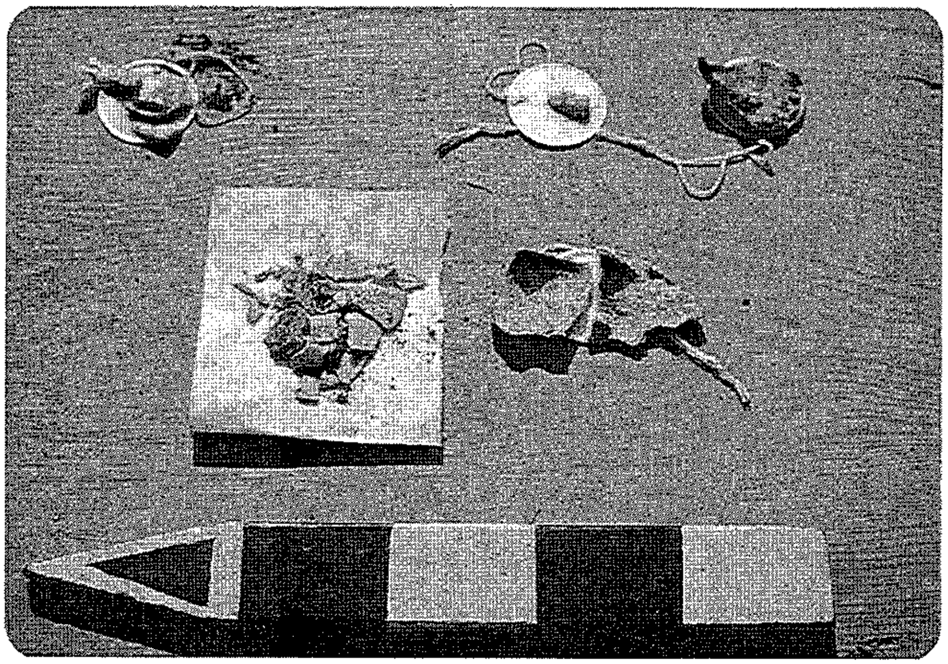


PHOTO 37 - Damaged Faunal Remains and
"Sand Dollar" in 10-20 cm Level

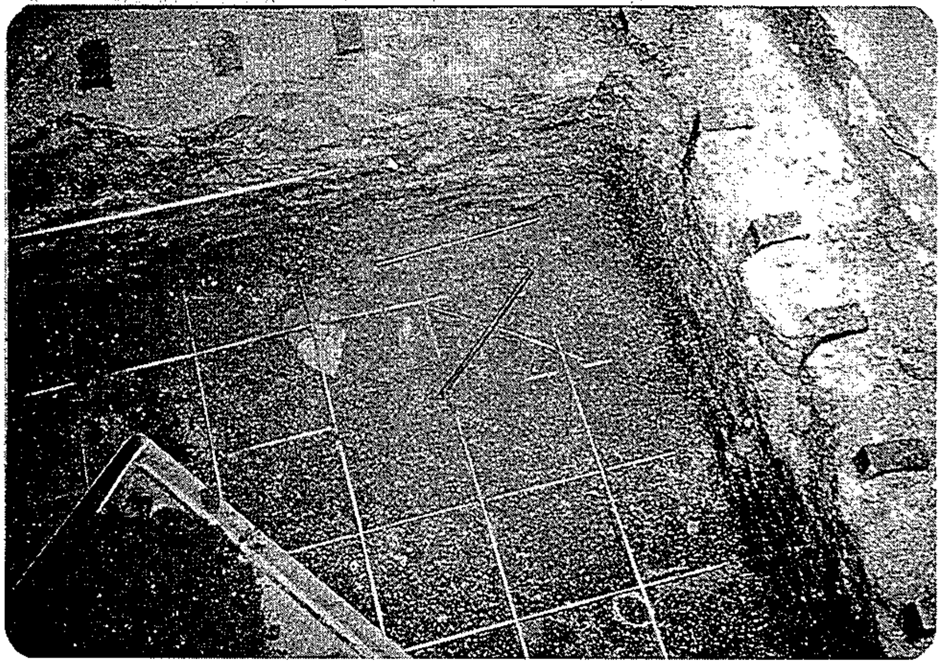


PHOTO 38 - In Situ Charcoal Sticks 10-20 cm Level

XII. GLOSSARY

GLOSSARY OF ARCHAEOLOGICAL TERMS

ARCHAEOLOGICAL SITE. Any area containing the material remains of past human cultures.

ARTIFACTS. Any product of human cultural activity (such as tools, weapons, houses, etc.).

CULTURAL MATERIAL. Material remains produced by human activity as opposed to noncultural materials which are identified as the physical manifestations of natural phenomena (see definition of noncultural materials below).

FAUNAL REMAINS. Animal bones often found within archaeological sites and interpreted either as the product of the butchery and consumption of meat or the death of animals living on, in or about an archaeological site.

GROSS MORPHOLOGICAL CHANGES. Changes in the overall physical form of an artifact. These include breakage and small damage scars but _not_ chemical changes or changes of a microscopic level.

MANO. From the Spanish _la mano_ ("hand") -- a loaf-shaped handstone used for grinding seeds, meat or pigment on a millingstone or "metate".

METATE. From the Aztec _metatl_, a stone slab upon which seeds and nuts were milled with the aid of a mano.

MIDDEN SOILS. A deposit marking a former habitation which contains such materials as discarded artifacts, bone and shell food refuse, charcoal, ash, rock and other remains. The deposit is usually of dark color and high in organic content.

MORTARS. A milling basin often made of stone used as a device for the pounding of seeds and nuts (used in conjunction with a pestle).

NONCULTURAL MATERIAL. Objects identified as products of natural forces (i.e., unmodified invertebrate remains, noneconomic animal bones, natural rocks, etc.). These are items which have not been influenced by human agents. See definition of cultural material above.

OLIVELLA. A genus of marine invertebrates of purple-white hue, the shell of which was commonly used by California Indians in the manufacture of beads.

POTSHERDS. Fragments of pottery from a broken ceramic vessel. Items of this nature are common constituents of some archaeological sites.

STRATIGRAPHY. Cultural and natural strata or layers often found in archaeological and geological deposits.

TRIAXIAL SHEAR TEST. A cylindrical soil sample is tested in a chamber by applying constant confining pressure to the sides of the sample through air or liquid and applying increasing vertical axial load to the ends of the sample to produce failure. This test duplicates actual field conditions and is used to determine apparent angle of internal friction and the apparent cohesion of soils.

TWO-INCH CALIFORNIA SAMPLER. A steel tube lined with 2-inch diameter by 4-inch long brass tubes which can be either pushed hydraulically or driven by a free fall hammer into soil to obtain undisturbed soil samples for testing.

XIII. APPENDIX

State of California

APPENDIX A

Business and Transportation Agency

Memorandum

To : J. O. Gray

Date: March 21, 1978

File : 11-SD-15, PM R40.4-R42.9
Gopher Cyn. to S. of
Lilac Road
11203-095061
Archaeology

From : R. D. Allen
DEPARTMENT OF TRANSPORTATION - District 11

Subject: SIMULATED FILL LOADINGS ON MIDDEN SOIL AND ARTIFACTS

This memo supplements item 2D of our memo dated March 20, 1978, regarding evaluation of soils and design data for Archaeology Sites SDi-4807, 4808, and 4556.

Test Procedure

Representative midden soils from the above sites and an assemblage of likely-to-be found artifacts (See figure 1) were loosely placed in a 6" diameter by 8" tall cylindrical mold. These mixtures were then hydraulically loaded to 1932 lbs. (68.3 psi), a load equivalent to the maximum fill height to be placed on any one site: 74 feet with an assumed density of 133 pcf.

Test Results

After loading, the artifacts were carefully removed from the midden soil and any alterations were noted and delineated (See figure 1).

The same group of artifacts was used in all three tests in the sequence: Test #1, SDi-4808 soil; Test #2, SDi-4807 soil; and Test #3, SDi-4556 soil. Data pertinent to this testing is contained in Table 1. Figures 2 and 3 are photographs of the artifacts and test equipment used.

Testing was performed by Mike Wagner and Al Nichols of Caltrans Transportation Laboratory. Caltrans employees witnessing the testing were: R. D. Allen, G. F. Warn, K. Sharp, J. O. Gray, T. R. Vasquez, and D. W. Gray.

Conclusions

Alteration to shell and bone artifacts during testing was very minor, consisting of about 1 mm wide by 8 mm long edge break offs (See figure 1). Of three pottery cherds, only the red one was altered (See figure 1). It experienced a minor edge break for Test #1, a vertical, clean break for Test #2, and a horizontal crack for Test #3. Repeated loadings and unloadings on this pottery fragment probably biases the damage incurred.

No crushing or pulverizing type damage occurred to the artifacts during testing. The alterations that did occur should not be considered a significant impact to archaeology resources at the sites involved.

G. F. Warn for

R. D. Allen
District Archaeological Preservation Coordinator

GFW:MW:dr
cc: JOGrasberger
TRVasquez
DLFrink-HQ. O.E.P.
RNClark
GFWarn
MWagner

Attachments

TABLE 1 - TEST DATA

TEST NO.	MIDDEN SOIL SOURCE	WT. SOIL AND ARTIFACTS-LBS*	INITIAL HEIGHT-INCHES	FINAL HEIGHT-INCHES	INITIAL WET DENSITY PCF	FINAL WET DENSITY PCF
1	SD1-4808	10.2	7.7	5.7	81.0	109.4
2	SD1-4807	10.3	6.8	6.1	92.6	103.2
3	SD1-4556	12.3	7.2	6.8	104.4	110.5

* Artifacts = 0.3 lb.

Figure 1.

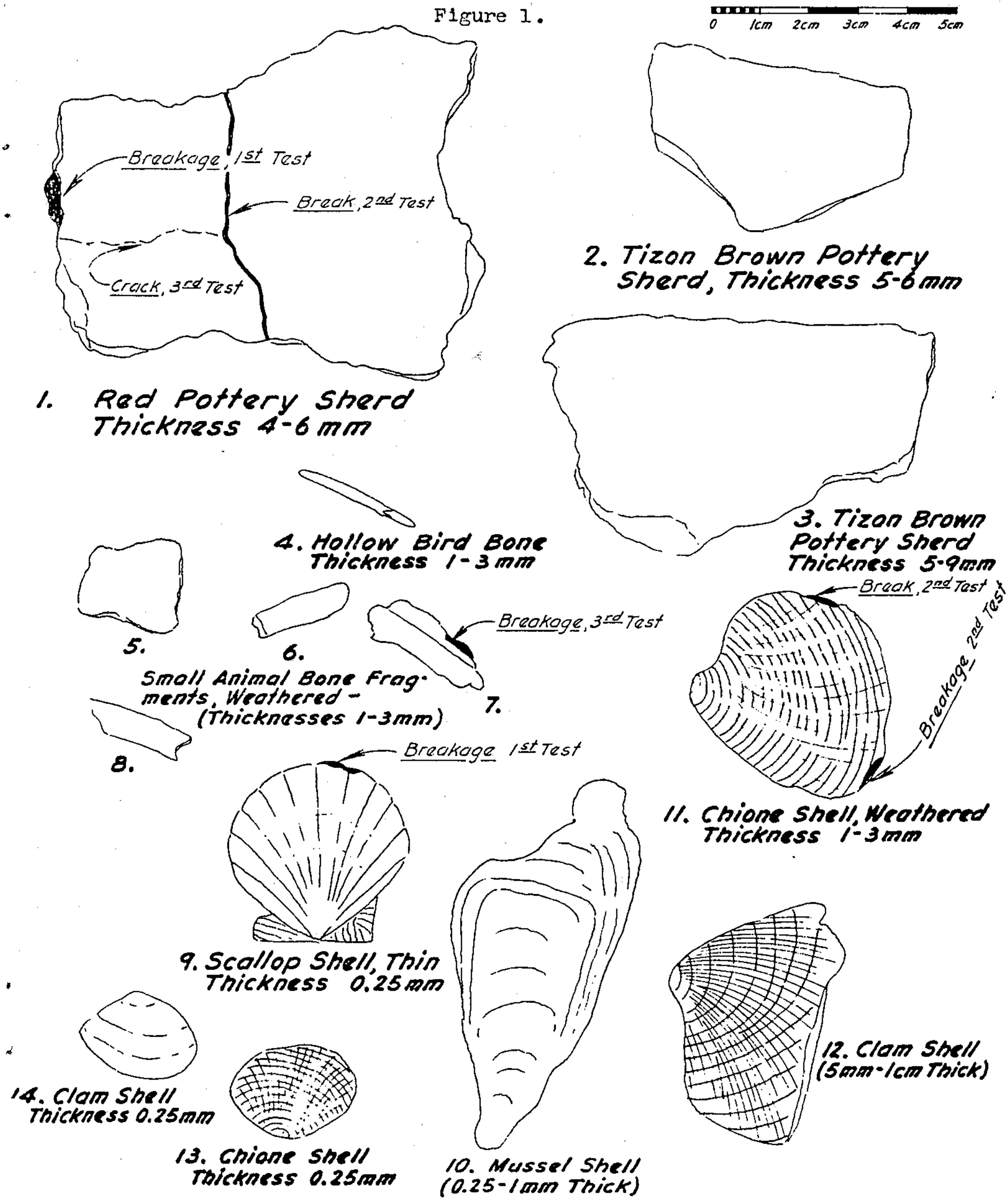
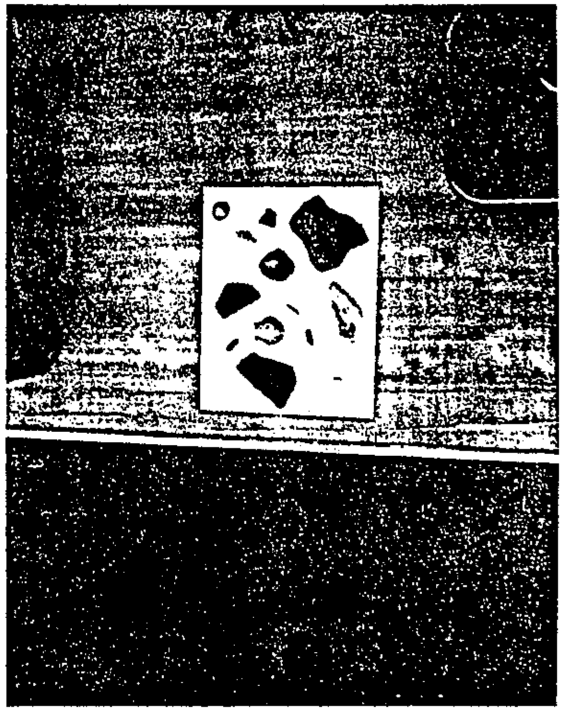

0 1cm 2cm 3cm 4cm 5cm
Breakage, 1st Test
Break, 2nd Test
Crack, 3rd Test
1. Red Pottery Sherd
Thickness 4-6 mm
2. Tizon Brown Pottery
Sherd, Thickness 5-6 mm
3. Tizon Brown
Pottery Sherd
Thickness 5-9mm
4. Hollow Bird Bone
Thickness 1-3 mm
5.
6.
7.
8.
Breakage, 3rd Test
Small Animal Bone Fragments, Weathered -
(Thicknesses 1-3mm)
Break, 2nd Test
Breakage 2nd Test
11. Chione Shell, Weathered
Thickness 1-3mm
Breakage 1st Test
9. Scallop Shell, Thin
Thickness 0.25mm
10. Mussel Shell
(0.25-1mm Thick)
12. Clam Shell
(5mm-1cm Thick)
13. Chione Shell
Thickness 0.25mm
14. Clam Shell
Thickness 0.25mm

Figure 2.

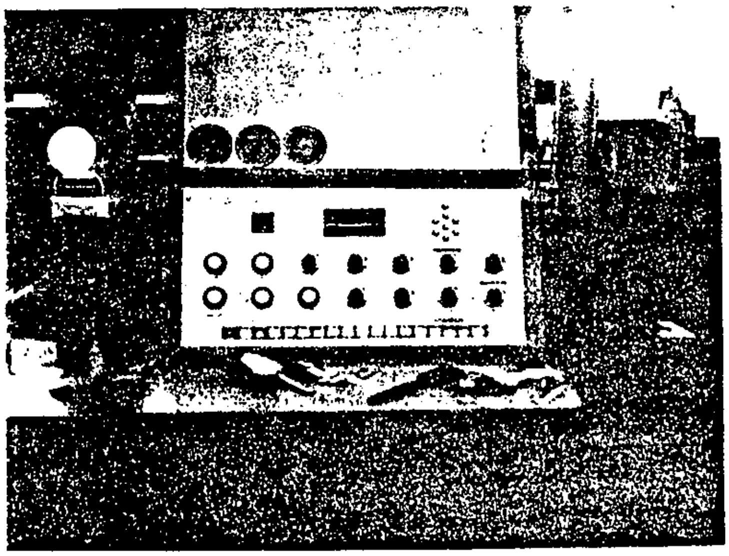


1. Picture of shells, pot sherds and bone used in compaction tests.

2. View of Cox Hydraulic Press used to compress midden soils to fill load equivalents.

Figure 3.

3. Close-up of Compression Cylinder loaded with midden soil and artifacts.



4. Close-up of Control Panel of Hydraulic Press.

State of California APPENDIX B Business and Transportation Agency

Memorandum

To : J. O. Gray

Date: March 21, 1978

File : 11-SD-15 S. of Gopher C.
Rd. to S. of Lilac Road
40.4-42.8
11203-095061
Archaeology

From : DEPARTMENT OF TRANSPORTATION - District 11

Subject: CHEMICAL EVALUATION OF MIDDEN SOILS AND PROPOSED D.G. COVER, SITES SDi 4807, 4808 AND 4556

This memo is in reply to your memo request of March 13th to evaluate soil chemical characteristics at the above archaeological sites and compare them with those of the D.G. material that could be used to cover these sites.

Typical soil samples were collected at each site and D.G. was collected at two locations in the designated area between Stations 1963 and 1970 Right Lane, at a depth of 10 to 12 feet below O.G. The samples were returned to the certified District 11 Lab where pH and moisture tests were run. The latter operation was to convert the soluble salts to a dry weight basis.

Three hundred grams of each - #8 sieved sample were soaked for 18 hours in 900 ml deionized water to put soluble salts into solution. One pint of supernate was drawn from each sample and shipped to Caltrans Headquarters certified Lab in Sacramento. There the samples were centrifuged to clarify them. They were then chemically analyzed by the atomic absorption spectrophotometry method. Quantitative tests were run for phosphorus, calcium, magnesium, sodium and potasium, all common soil ingredients. Potasium was run because it can be an indicator of bone quantities in midden. A table of test results follows:

PRELIMINARY LABORATORY SUMMARY OF CHEMICAL TESTING

Soil Sample	SDi-4556	SDi-4807	SDi-4808	Dark D.G.	Light D.G.
% Moisture	6.7	10.7	16.3	4.8	10.3
pH	6.8	8.3	6.2	6.5	6.8
Phosphorus*	2.68	1.78	3.54	0.10	0.92
Calcium*	7.19	44.25	4.38	6.72	5.80
Magnesium*	1.54	3.09	1.20	2.56	3.75
Sodium*	3.27	4.46	2.92	16.64	21.48
Potassium*	8.18	18.18	12.78	1.28	1.26

*Parts per million of dry midden or decomposed granite (D.G.) soil.

In summary, we see no evidence for significant chemical changes in midden soils if they are covered by a one foot thick D.G. blanket.

G. F. Warn for

R. D. Allen
District Archaeological Preservation Coordinator

GFW:MW:dr
cc: JOGrasberger
RNClark
TRVasquez
GFWarn
DLFrink - HQ OEP